

# Delivering London 2021: ICT implementation and operations

**INSIDE THIS SPECIAL INTEREST PUBLICATION** Selected papers highlighting the rich diversity of ICT which came together to deliver the most digitally connected Olympic and Paralympic Games ever. A sequel to Delivering London 2012: ICT Enabling the Games, published prior to the Games in 2011.



# TECHNOLOGY IS GREAT BRITAIN

**TECH CITY, LONDON: THE LARGEST AND  
FASTEST-GROWING TECH CLUSTER IN EUROPE**

*LONDON  
Flickr Geotag Map*

[www.ukti.gov.uk](http://www.ukti.gov.uk)



# Contents

---

<b>About the ICT Knowledge Transfer Network, the Institution of Engineering and Technology and UK Trade and Investment</b>	3
<b>Delivering London 2012: ICT Implementation and Operations</b>	4
Introduction and forewords	
London 2012 statistics and numbers	
<b>Abbreviations</b>	11
<b>Paper 1 - London 2012 – Technology Overview</b> David Finch	14
<b>Paper 2 - Wireless and Mobile Technologies: Overview and Introduction</b> David Finch	18
<b>A - Spectrum Management at the London 2012 Games</b> Peter Bury	20
<b>B - Wireless and Spectrum: The BBC Perspective</b> Alex Russell	24
<b>C - London 2012 – review of the Olympic Family Mobile Service and public mobile performance during the Games</b> Steve Hurdle	26
<b>D - London 2012 Wi-Fi – delivering the best connected Games</b> Eddie Green	29
<b>E - Portable Mobile Radio solution deployed across Olympic venues and the Olympic Route Network</b> Michael Brogden and Russell Selwyn	35
<b>Paper 3 - Cyber Security and Resilience Overview</b> David Finch and Vijay Samtani	38
<b>A - Corporate Infrastructure</b> David Finch	42
<b>B - Games-Time Website</b> David Finch and Vijay Samtani	44
<b>C - BT Communications – Internet and Network Security</b> Stuart McMillan	47
<b>D - Atos Games Information Technology Systems Security</b> Shailesh Chauhan and Clive Grethe	51
<b>Paper 4 - Online services overview</b> Stuart Revell	55
<b>A - London 2012 website and mobile applications</b> David Finch and Chris Hudson	56
<b>B - Spectator Journey Planner: Getting you to the Games on Time</b> Jonathan Shewell-Cooper	60
<b>C - BT, social media monitoring</b> Andrew Parker	63
<b>D - Online Content – 2012 – A Big Year for the BBC</b> Ben Ross	65
<b>E - Super Hi-Vision – The BBC and NHK</b> John Zubrzycki, Alex Russell and Yoshiaki Shishikui	68
<b>Paper 5 - Managing the Delivery of Games Information and Communication Technologies: an overview</b> Gerry Pennell OBE	71
<b>A - BT Technology Project Management for right first time</b> Tim Boden	74
<b>B - Atos Programme Delivery</b> Michele Hyron	77
<b>Paper 6 - Operating the technology at the Games: an overview</b> Gerry Pennell OBE	81
<b>A - BT approach, technology operations</b> Andrew Parker	84
<b>B - Atos Information Technology Operations</b> Pieter-Jon Buitelaar	86

(continued overleaf)

(contents continued)

<b>Paper 7 - Supporting third-party equipment overview</b> David Finch	91
<b>A - BT supporting third-party equipment</b> Tim Boden	92
<b>B - Atos – BYOD at the Games</b> Shailesh Chauhan and Clive Grethe	95

We would like to thank the following groups for their involvement in the review of papers in this publication:

ICT KTN committee

IET Information and Communications Sector committee

IET Multimedia Communications Network committee

LOCOG

Editorial Panel

- Phil Clayson, BEng(Hons), MBA, CEng, C.Mgr, FIET, FCMI, Farncombe Technology Ltd

- Simon Gauntlett, MIET, MEng, CEng, Digital TV Group, UK

- Philip Hargrave, ICT KTN

- James Hayes, 'Engineering & Technology' magazine, UK

- Eddie Murphy, ICT KTN

- Stuart Revell, ICT KTN, UK

- Matt Wilson, CEng, CITP, FIET, FBCS, FloD, FCIM, Crosby Communications PLC, UK

- Simon Yarwood, The IET, UK

The paper used to print this publication is made from certified sustainable forestry sources.



The Information and Communication Technologies Knowledge Transfer Network (ICT KTN) was established by an industry-led group of key players in the sector. It is funded by the Technology Strategy Board, which is an executive non-departmental public body, established by the UK Government in 2007 and sponsored by the Department for Business, Innovation and Skills.

We focus on Knowledge Transfer as a stimulus to economic growth, seeking to bring a competitive advantage to the UK by facilitating the development and take up of information and communications technologies and their adoption as key enablers in other industries.

We facilitate knowledge exchange within the ICT segment and adjacent sectors, acting as a catalyst to accelerating innovation and we focus on fixed and mobile communications, information technologies and broadcasting networks.

We are a membership-based organisation and our membership spans the entire value chain of vital components including, equipment manufacturers, solution providers, system integrators, network operators, service providers, component manufacturers, application developers, broadcasters and universities. Membership is free and we currently have more than 4000 members.

Our approach is highly collaborative and we work closely with other organisations in the field to deliver topical events and thought leadership. This Network of Networks approach has proven highly successful as a mechanism for knowledge transfer.

We also work closely with other sectors such as transport, education, health and energy – for which ICT are transformational technologies.

Visit [www.ictktn.org.uk](http://www.ictktn.org.uk) or email [info@ictktn.org.uk](mailto:info@ictktn.org.uk) for more information.

---

## Information & Communications



The Institution of Engineering and Technology (IET) has recognised that the demands on the modern engineering community have changed. By prioritising five sectors: Built Environment, Design and Production, Energy, Information and Communications and Transport, the IET has provided an access point to the vast array of knowledge, experience and content available to members and the global science, engineering and technology community.

The Information and Communications Sector's vision is to become a focal point for all those working or interested in information and communications. It also recognises the importance of promoting professional qualifications and certifications in this field. Its aims are:

- to provide up-to-date news and information for professionals and other stakeholders
- to partner with strategically aligned trade associations and industry bodies
- to bring together relevant IET products and services related to the sector
- to identify key hot topics and activities to ensure the IET deploys its expertise where it will have the greatest impact
- to publicise and represent the information and communications engineering profession to a wider audience.

For more information, visit [www.theiet.org/info-comms](http://www.theiet.org/info-comms)



UK Trade & Investment is the Government Department, which helps UK-based companies succeed in the global economy. We also help overseas companies bring their high-quality investment to the UK's dynamic economy acknowledged as Europe's best place from which to succeed in global business.

UK Trade & Investment offers expertise and contacts through its extensive network of specialists in the UK, and in British embassies and other diplomatic office around the world. We provide companies with the tools they require to be competitive on the world stage.

For more information, visit [www.ukti.gov.uk](http://www.ukti.gov.uk)



# Delivering London 2012: ICT Implementation and Operations

## Introduction and forewords

London 2012 was a once-in-a-generation opportunity to showcase everything that makes Britain great in order to generate long-term economic benefit for UK businesses and the UK economy through trade and investment opportunities.

The winning, planning, delivery and legacy of the Olympic and Paralympic Games have called upon all the qualities that make the UK stand-out in the global economy; the innovation and energy our creative industries brought to London's bid; the skill our advanced engineering and infrastructure specialists have used to transform Stratford, East London; and the know-how and vision that helped us stage the first truly digitally connected green Games.

The London Olympic and Paralympic Games demonstrated the strength of the UK Information and Communication Technologies (ICT) sector. To deliver the pictures, texts, phone calls and video required for the Games – both for their broadcasting and to ensure smooth communication and hence efficient organisation – a mammoth task began shortly after the awarding of the bid to London in 2005, of creating ICT systems that were fit for the most digitally enabled Games ever.

- These were the first ever social media Games – with [www.London2012.com](http://www.London2012.com) becoming one of the most visited sports website in the world with 431 million visits, 109 million unique users, 15 million app downloads and 4.73 billion page views. An estimated 4 billion spectators viewed the Games worldwide.
- The BT Group designed and delivered the first ever converged communications network for a summer Olympics, carrying voice, data, mobile, broadcast and wireless internet traffic on one seamless, all-purpose network. This converged network meant improved energy efficiency, avoiding the need to build and power separate networks, and maximising the potential for its reuse after the Games. At peak times, the network was carrying 60 gigabits of information a second, between 80 000 connections across 94 locations (four times the network capacity of the Beijing Games), setting the bar for future Olympics and other major global sporting events.
- The Olympic Park will become part of the rapidly growing digital hub of 'Tech City' in East London, future home to such ICT giants as Cisco, Vodafone, Google and Intel. The addition of the Olympic Park's world-class facilities and the legacy of its telecommunications network will enhance the hub's reputation as one of Europe's most dynamic places to set up a tech, digital or creative media company. Out of every pound sterling that has been spent on the Olympic build, 75 pence is being invested in the regeneration of East London, which will further benefit from the development of Tech City.

The UK is one of the most important and sophisticated markets for ICT, some notable examples:

- Technology designed by UK company ARM, is used in more than 95% of the world's mobile handsets and over 25% of all smart electronic devices.
- The total Information technology (IT) & telecom workforce in the UK now comprises 1.5 million individuals – 5% of the total current UK workforce. This is made up of 900,000 specialists within the IT & telecom supply industry and a further 600,000 working as IT or telecom professionals in other industries.

- The UK is a strong market for technology, with some of Europe's most voracious consumers of technology.
- The UK is Europe's leading market for software and Information Technology services with a market value of €61 billion in 2011.
- London's Tech City has grown dramatically to become the capital's leading destination for digital, creative and high-technology companies. In just three years, it has expanded naturally from around 15 companies to over 300 – growth that is set to continue, with the UK Government actively supporting the area's development.

## **Gerry Pennell OBE, Chief Information Officer, London Organising Committee of the Olympic and the Paralympic Games**

The typical athlete, spectator, television (TV) audience or digital consumer of the spectacular set of sporting events that was the London 2012 Olympic and Paralympic Games would probably have little appreciation of the complexity of the underlying digital technology that – in the 21st century – is required to make it possible for the world to consume the Games experience in the way that the world expects.



The timing, scoring or other measurement of the athletic performance itself is of course essential for the athletes themselves but broadcasters, journalists and press agencies are increasingly dependent on technology services provided by the organising committee, and its partners, to keep them abreast on a play-by-play, live results basis of the progress of the competition, the status of records and, of course, the medals table.

Audio-visual technologies are increasingly important to support the adjudication of the events as well as the enhancement of the spectator experience through music-quality public announcement systems and video-boards.

Alongside this, the operations of the Games are entirely dependent on a variety of technology services from software applications to various telecommunications services, including radio and on spectrum planning and management services which, in the case of London, were provided by Ofcom.

Prior to the Games, the press and several other constituencies expressed great scepticism about the ability of the UK – and the organising committee itself, to deliver the technology required to time, quality and budget. Specific areas of concern that were raised included:

- the ability to deliver the scale and complexity of technologies within the fixed timeframe required
- the expectation that mobile voice and data services would not be available at the Olympic sites
- a fear that cyber-attacks from terrorist, hacktivist or other organisations would 'bring down the Games' and otherwise disrupt operations.

In practice, all these challenges – and more – were successfully surmounted and, unlike at previous Games, technology never became a story – because it worked.

As the man privileged enough to be leader of the staff, sponsors, suppliers and volunteers who delivered the technology for the Games it gives me great pleasure to introduce this set of papers that lay out how the many and disparate technologies required to deliver the Games were successfully delivered.

There are various legacies from these Games, including – by way of example – the additional network capacity implemented by BT and the rapid skills development experienced by many, including 40 privileged student interns in 2011/12.

However, my personal ambition for the technology legacy from these Games is a revitalisation of confidence in the UK that, when managed correctly, this nation has the skills in depth, the management and leadership capability and the committed personnel that allows the delivery of major projects, despite some of the exceptional challenges that London faced.

I do hope you enjoy reading these papers!

## Philip Hargrave, ICTKTN CEO, ICT KTN

The ICT KTN is delighted to have been associated with the formulation of this special interest publication. A sequel to *Delivering London 2012: ICT Enabling the Games*, which detailed the ICT technology that had been developed to underpin the London 2012 Olympics and Paralympic Games, it sets out to celebrate the performance of that technology during what was the most digitally connected Games ever held.



Membership of the ICT KTN is open to all involved in any way in the ICT value chain, from university researchers, through those in enterprises of all sizes working in the converging sectors of communications, information technology and broadcasting, to those in adjacent sectors for which ICT is transformational. With funding from the Technology Strategy Board, we focus on Knowledge Transfer as a stimulus to economic growth. The success of the rich diversity of innovative ICT technologies that were central to the overwhelming success of the London 2012 Games presents the UK with a once in a lifetime opportunity to position itself as the ICT partner of choice in major projects worldwide. From the ground breaking capacities of the mobile phone and Wi-Fi installations deployed across the nine venues that reliably served more than 160,000 spectators at any given time, through the 432 million visits to the London Organising Committee of the Olympic and Paralympic Games (LOCOG) website during the Games, to the 24 high definition TV channels streamed each and every day of the Games, London 2012 was a tremendous ICT success for the UK; a success that we must celebrate and on which we can build a substantial and long-lasting legacy.

For more information, visit [www.ictktn.org.uk](http://www.ictktn.org.uk)

## Andy Hopper, IET President, IET

Despite difficult economic times, it is clear that innovation is alive and well in the UK. This was evident in 2012 when the eyes of the world were on London as the UK hosted its biggest sporting event in decades, the Olympic and Paralympic Games, with a new purpose-built park in London.



Behind the preparations was an incredible array of engineering and technology, creating a world class environment of construction, communications and transport infrastructure, hospitality, tourism and more. In all these areas, it was the engineers and technicians who enabled successful outcomes.

The IET, Europe's largest professional group for engineers and technicians, used this once in a lifetime opportunity to demonstrate the pivotal role that engineering and technology played in the Games. An effective way of doing this is through working in partnership with organisations such as the ICT KTN and UK Trade and Investment.

In a world where disciplines merge, today's engineers and technicians need a broad understanding of engineering and technology issues. As a multidisciplinary organisation, the IET brings these issues together within five focused sectors; one of which is Information and Communications.

The sector provides professionals with a 'lens' to focus on knowledge services, events, professional support, news, views and communities of like-minded people in the Information and Communications field. Those familiar with the IET will know that it is Europe's premier organisation for the engineering community.

The IET has over 150 000 members in 127 countries who are part of our professional home for life, connecting professionals through a global network. Furthermore, as a worldwide community of professionals we are united in the purpose of sharing knowledge and promoting the benefits we bring as a profession.

For more information, visit [www.theiet.org/info-comms](http://www.theiet.org/info-comms)

## UKTI Nick Baird, CEO, UK Trade and Investment

I am delighted that the UK ICT industry so ably demonstrated its world beating technology as part of a very successful Olympic and Paralympic Games held in London in the summer of 2012.



Delivering the 2012 Games has become one of the largest single ICT success stories of the 21st century. A rich diversity of technologies helped to enable both the smooth running of events and the changing landscape of mobile technologies that made London the most wirelessly enabled Olympic Games ever, putting users at the heart of the Olympic experience.

---

This publication sets out the very best of British ICT project management, innovation and technology and through the use of actual case studies shows how and why UK companies were so successful and what can be learnt from our experience in delivering London 2012.

The coming years will see many more major global sporting events, technology challenges and large projects, that will provide an opportunity for UK companies working in partnership with overseas companies to pass on our experience of London 2012, to introduce you to their technologies as well as helping to design, develop and implement the ICT technologies required to enable future successful events and major projects.

There is much that we can do by working together to deliver the very best global sporting events and major technology projects with UK expertise at its heart.

## London 2012 statistics and numbers

### *Sporting events*

- Equivalent to **46 World Championships** at the same time:
  - **300 medal events** for **26 Olympic Sports** in **34 venues** over **19 days** of competition
  - **471 medal events** for **20 Paralympic sports** in **20 venues** over **11 days** of competition
  - **36 competition venues** and **41 training venues**
- **10 490 Olympic and 4237 Paralympic Athletes**
- **11.5 million tickets** (8.8 m Olympic, 2.7 m Paralympic)
- **22 000 media and broadcasters** for the Olympic Games and **6500 media and broadcasters** for the Paralympic Games
- Public transport, more than a million additional journeys using public transport on the busiest day of the Games:
  - **62 million journeys** were made on London Underground, 35% more than normal
  - A record **4.5 million journeys** were made on the London underground during a single day in the Games
- **70 000 London 2012 Games Makers** selected from **240 000 applications**.

### *Technology and usage in numbers*

#### *Olympic Games-Time Statistics*

##### **Wide Area Network (WAN)**

- 17 × optical spectrum access, 8 × optical spectrum extended access, 75 × Ethernet Access Direct, 13 × Etherflow, 14 × BT leased line internet access, 15 × Internet Protocol Clear delivered to 71 locations.

##### **Cabling**

- 73 competition and non-competition venues, 5500 km internal and 150 km armoured cabling, 65 000 cabled ports, 250 000 patch leads.

##### **Local Area Network (LAN)**

- 819 CCFs, 600 Cabinets, 55 venues staged, at peak deployed 4250 services/week 58 000 Admin LAN ports across 1841 access switches
- 20 000 Games LAN ports across 1031 access switches
- 481 Distribution and fibre switches.

##### **BT-regulated Services**

- 2818 fibre to the premises @ ALV, 85 fibre to the curb @ WEV[Soft Break]380 asymmetric digital subscriber line technology lines and c.3000 public switched telephone network lines
- 14 Ethernet Private Circuit orders and 2 multiprotocol label switching.

##### **Core Infrastructure**

- 2 off Olympic park POPs – 26 cabinets each (12 for NTEs and 14 for core equipment)

- 4 hour uninterruptible power supply, redundant power distribution and video and vibration monitoring plus man-guarding.

### **Cable Television (CATV)**

- 47 venues, covering 7000 co-axial outlets and 10 000 TVs
- Interfaced to five existing distribution infrastructures
- Supported 5000 tabled press positions and 3000 apartments
- Delivered 40 channels of Olympic content plus 20 channels of commercial and Freeview.

### **Internet Protocol Telephony (IPT)**

- 14 500 Voice over Internet Protocol accounts configured and 8000 Voicemail
- 13 458 telephones delivered, peak usage 10 500.

### **Internet**

- 6380 rate card internet access accounts registered
- 2.35 billion security system messages logged
- Blocked 200 million malicious connection requests, 11 000 per second in one Distributed Denial-of-Service attack.

### **Wireless**

- 644 Back of House Access Points deployed in 208 areas in 43 venues
- 850 Front of House (FoH) Access Points deployed in 7 venues plus Common Domain.

### **Olympic Broadcasting Service (OBS)**

- 273 standard orders supporting 287 high definition (HD) video feeds, 2293 full-duplex audio circuits, 91 × 1 G broadcast data feeds and 24 × E1 circuits across 59 locations.

### **Mobile Infrastructure**

- 31 dedicated Olympic Family Mobile Service dedicated in-building solutions
- 18 multi-operator Olympic Park temporary towers and rooftop structures
- 16 multi-operator temporary towers outside Olympic venues
- 2 multi-operator permanent structures (one off the Olympic Park, one on)
- 11 in-building multi-operator FoH solutions
- Innovations included diverse 2 G/3 G backhaul for key venue resilience and remote connectivity (because of lack of venue space) for Olympic Park FoH areas.

Olympic family mobile products and services:

- 19 000 SIMs
- 14 700 products staged and delivered.

## **London 2012 WEBSITE and mobile Apps**

- 4.73 billion web pages views
- 1.3 petabytes of data delivered
- Daily peak of 1.8 million unique visitors
- 109 million unique users during Games time
- 493 000 peak concurrent users
- 12 million downloads of results App
- 2.8 million downloads of Join In App.

## **BBC Olympic coverage in numbers**

- 1.67 billion linear TV viewer hours of the BBC's Olympic Coverage
- The opening ceremony peaked at 27.3 m viewers with an average of 23.4 m, an 84% audience share
- 3.9 m requests for the opening ceremony from BBC iPlayer during the Games
- The Closing Ceremony peaked at 26.3 m viewers with an average of 23.2 m, an 82% audience share
- 90% of the UK population watched at least 15 min of the coverage
- By comparison 61% of the UK population watched Kate & William's Royal Wedding and 69% watched the Diamond Jubilee coverage
- 24 HD and 24 standard definition (SD) live streams available on digital satellite, cable and online
- 24.2 m viewers to the 24 SD, 24 HD and Freeview Red Button streams throughout the Games (compared with a total of 7.6 m red button viewers in Beijing)
- BBC Red Button viewing hours totalled 191 m across the Olympics
- BBC Red Button viewing accounted for 12% of total Olympics viewing
- Four times Beijing's coverage – 24 live HD and SD streams, 2500 h of coverage, on four screens
- A page for every athlete (all 10 490 of them), sport, country and event
- 57 m global and 37 m UK browsers to bbc.co.uk
- 111 m video requests across all online platforms including 12 m requests for video from mobile devices
- 1.9 m downloads of our Olympics smartphone App in 2 weeks
- An average of 9.5 m (global) and 7.1 m (UK) browsers per day, easily breaking all previous records (previous record for a single day was 7.4 m global and 5.7 m UK)
- 9.2 m UK mobile browsers to the BBC's Olympics coverage
- Mobile browsers accounted for 34% of all daily browsers to BBC's Olympic coverage (39% on weekends).



## Abbreviations

Abbreviation	Definition
2G	2 <sup>nd</sup> Generation Mobile
3.5G Data	3G High-Speed Packet Access
3G	3 <sup>rd</sup> Generation Mobile (UMTS)
Adobe HDS	HTTP Dynamic Streaming
ADSL	Asymmetric Digital Subscriber Line
AIS	Acceptance into Service
AOA	Angle of Arrival
AP	Access Point
API	Application Programming Interface
Apple HLS	HTTP Live Streaming
ARP	Address Resolution Protocol
ATOC	Alternative Technology Operations Centre
BDF	Broadcast Data Feed. Olympic combined video and results data feed
BIS	Department of Business, Innovation and Skills
BoH	Back of House
BS	Base Station
BTnet	BT leased line internet access
BTS	Base Transceiver Station (Mobile base station)
BYOD	Bring Your Own Device
CATV	Cable Television
CCF	Cross-Connect Frame
CDN	Content Distribution Network
CDN	Content Delivery Network
CDR	Critical Design Review

*Continued*

Abbreviation	Definition
CERT	Computer Emergency Response Team
CGS	Core Games System
CIA	Confidentiality, Integrity and Availability
COTS	Commercial off the Shelf
CPNI	Centre for Protection of National Infrastructure
CSDR	Critical Service Design Review
dB	Decibels
dBi	Decibels isotropic (gain of antenna)
DDOS	Distributed Denial-Of-Service attack
DIA	Direct Internet Access
DNS	Domain Name System
DSCP	Differentiated Services Code Point (classifying and managing network traffic and providing quality of service)
E1	2.048 Mbps Plesiochronous Digital Hierarchy link
E1 PDH	2.048 Mbps Plesiochronous Digital Hierarchy link
EAD	Ethernet Access Direct
EIRP	Equivalent Isotropically Radiated Power
FoH	Front of House
FTTC	Fibre To The Curb
FTTP	Fibre To The Premises
GNAT	Games Network of Accessible Transport
GOE	Government Olympic Executive
GoS	Grade of Service

*Continued*

Abbreviation	Definition
GPS	Global Positioning System
GSM	Global System for Mobile communications
HD	High Definition (Video)
HD-WiFi	High Density Wi-Fi
HIPS	Host Intrusion Prevention System
HTTP	Hypertext Transfer Protocol
IBC	International Broadcast Centre
IBNS	Identity-Based Network Services
ICT	Information and Communication Technologies
ICTKTN	Information and Communication Technologies Knowledge Transfer Network
IDS	Info Diffusion System
IEM	In Ear Monitor
IET	The Institution of Engineering and Technology
IOC	International Olympic Committee
IP	Internet Protocol
IPS	Intrusion Prevention System
IPSEC	Internet Protocol Security
IPT	Internet Protocol Telephony
IPTV	Internet Protocol Television
ISM	Industrial, Scientific and Medical License-Exempt Spectrum usage
ISP	Internet Service Provider
IT	Information Technology
ITIL	Information Technology Infrastructure Library ( <a href="http://www.itil-officialsite.com/AboutITIL/WhatisITIL.aspx">http://www.itil-officialsite.com/AboutITIL/WhatisITIL.aspx</a> )
ITL	Integration Test Lab
ITN	Integrated Transport Network
IVP	Interactive Video Player
JANET	Joint Academic NETWORK
JOOG	Joint Olympic Operators Group
JP	Journey Planner
JRB	Joint Review Board
KTN	Knowledge Transfer Network
LAN	Local Area Network

*Continued*

Abbreviation	Definition
LCD	Liquid Crystal Display
LDAP	Lightweight Directory Access Protocol
LOCOG	London Organising Committee of the Olympic and Paralympic Games
M2M	Machine to Machine communications
MAC	Media Access Control (Layer 2)
MIMO	Multiple-Input and Multiple-Output
MMS	Multimedia Messaging Service
MNO	Mobile Network Operator
MOC	Main Operations Centre
MPC	Main Press Centre
MPEG	Moving Picture Experts Group
MPLS	Multiprotocol Label Switching
NDPB	Non-Departmental Public Body
NTE	Network Terminating Equipment
OB	Outside Broadcast
OBS	Olympic Broadcasting Service
OCCT	Olympic Cyber Coordination Team
ODA	Olympic Delivery Authority
ODF	Olympic Data Feed
OFMS	Olympic Family Mobile Service
ORN	Olympic Route Network
ORR	Operations Readiness Review
OSA	Optical Spectrum Access
OSEA	Optical Spectrum Extended Access
OSS	Operations Support System
OZ	Openzone
PA	Public Announcemount
PC	Personal Computer
PDC	Primary Data Centre
PDF	Portable Document Format
PII	Personally Identifiable Information
PMR	Private Mobile Radio
PMSE	Programme Making and Special Events
PoE	Power over Ethernet
POP	Point of Presence

*Continued*

Abbreviation	Definition
PRN	Paralympic Route Network
PSTN	Public Switched Telephone Network
QA	Quality Assurance
QoS	Quality of Service
R&D	Research and Development
RBAC	Role Based Authentication and Control
RBS	Radio Basestation
RF	Radio Frequency
RRM	Radio Resource Management
RTMP	Real Time Messaging Protocol
S/W	Software
SAN	Storage Area Network
SD	Standard Definition (Video)
SDC	Secondary Data Centre
SHV	Super Hi-Vision
SIM	Subscriber Identification Module
SJP	Spectator Journey Planner
SLA	Service Level Agreement
SMS	Short Message Service
SQL	Structured Query Language
SSID	Service Set Identifier
TCC	Transport Coordination Centre
TDA	Technology/Technical Design Authority
TDM	Travel Demand Management
TDOA	Time Difference of Arrival
TER	Telecomms Equipment Room
TETRA	TErrestrial Trunked Radio
TfL	Transport for London
TLS	Transport Level Security
TOC	Technology Operations Centre

*Continued*

Abbreviation	Definition
TOGAF	The Open Group Architecture Framework ( <a href="http://pubs.opengroup.org/architecture/togaf8-doc/arch/">http://pubs.opengroup.org/architecture/togaf8-doc/arch/</a> )
TOR	Technology Operational Readiness
TPM	Trusted-Platform Module
TPO	Technology Programme Office
TTL	Time-To-Live
TV	Television
UHF	Ultra-High Frequency
UK CERT	UK Computer Emergency Response Team
UKTI	UK Trade & Investment
UMTS	Universal Mobile Telecommunications System
UPS	Uninterruptible Power Supply
URL	Universal Resource Locator
USB	Universal Serial Bus
VDR	Venue Design Review
VHF	Very High Frequency
VLAN	Virtual Local Area Network
VMS	Video Messaging Service
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
VRR	Venue Readiness Review
VTM	Venue Technology Manager
WAN	Wide Area Network
WCATV	Wireless Community Access Television
Wi-Fi	Trademark of the Wi-Fi alliance. Wireless Local Area Network technology (IEEE 802.11 family of standards)
WLAN	Wireless Local Area Network
XML	Extensible Markup Language



# Paper 1 – London 2012 – Technology Overview



## David Finch

Senior Manager, Architecture & Security, LOCOG  
<http://uk.linkedin.com/pub/david-finch/2/a21/361/>

In late 2011, The Institution of Engineering and Technology (IET) published *Delivering London 2012: ICT enabling the Games*, highlighting a range of key technologies being prepared for the Olympic and Paralympic Games. The purpose of this latest publication is to revisit those technologies and the associated operations surrounding them and summarise what was achieved during the London 2012 Games. With an extraordinarily successful Games delivered and much of the technology decommissioned, it is now possible to provide a greater insight into the solutions and services put in place, including some of the challenges encountered.

To recap some content from the earlier publication, the London Organising Committee of the Olympic and Paralympic Games (LOCOG) Technology Architecture Framework and a summary of services are provided in the following pages. The framework is loosely based on the OSI seven-layer model, and identifies services and their users, where the underpinning systems fitted into the architecture and their interdependencies along with the organisation(s) responsible for delivery (see Fig. 1 for a simplified version).

In terms of availability, the targets across the broad range of technology solutions were substantially met. Of course, with such a complex environment and so many ‘moving parts’ issues will occur and the operational responses managed through the Technology Operations Centre (TOC) were effective in quickly mitigating impact, proving

the value of the many test events and Technical Rehearsals carried out in advance of the Games (see Fig. 2).

Whilst these preparatory events could never be expected to cover every eventuality that might occur during the Games, they served extremely well in ensuring that the incident response processes were second nature across the organisation and individuals understood their roles and responsibilities.

## 1 Performance and capacity

Looking back on the Games, the significant time spent on planning and forecasting performance and capacity requirements was extremely worthwhile. In some areas, the actual capacity consumed was less than expected, for example contention for internet bandwidth was planned for but did not actually occur; however, had this been known for sure in advance it would not have resulted in a significant reduction in supporting infrastructure. Of course, demand exceeding available capacity represented a more significant risk during the Games because of the potential to have an impact on services and there was significant demand on mobile services that contributed to issues with the Cycling Road Race (on Saturday, 28 July) and to mobile services at Eton Dorney. In these cases, the response was again effective, for example, the subsequent road races did not experience a repeat of the issues seen with the first event.

LOCOG Technology – Architecture Framework

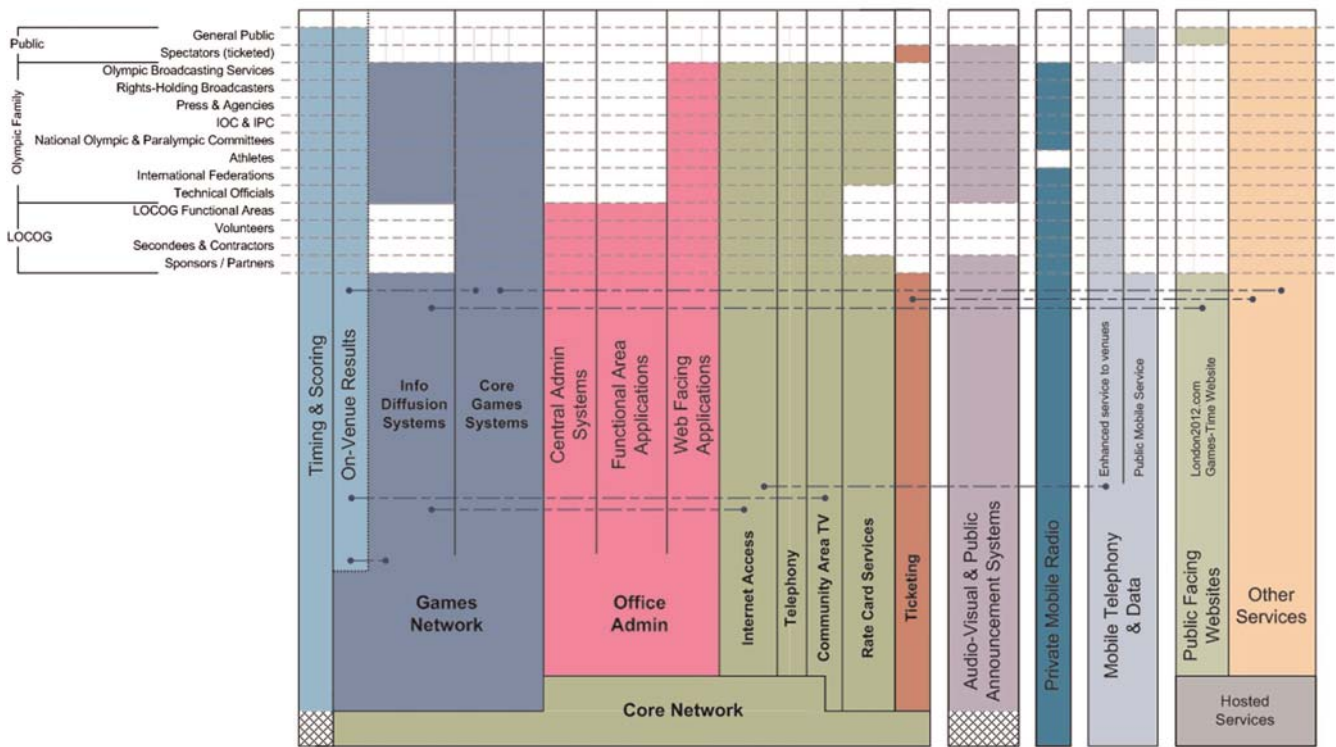


Figure 1 Architecture & Security Framework

Table 1

<p>Timing and Scoring</p>	<p>Systems deployed on or adjacent to the field of play to capture as accurately as possible the timing and/or scoring information appropriate to the sport. These systems employed purpose-built hardware, such as the starting blocks and touch pads used for swimming events</p>
<p>On-Venue Results</p>	<p>A small network of PCs, Laptops, Servers and Printers in each venue that received and processed information from Timing and Scoring, generating outputs for the scoreboard, TV Graphics and data feeds for onward distribution. Whilst in this case standard hardware platforms were used, software was again specific to the individual sport</p>
<p>Games Network systems provided by Atos, comprising of:</p> <ul style="list-style-type: none"> <li>• Info Diffusion Systems</li> <li>• Core Games Systems</li> </ul>	<p>These systems received the data from On Venue Results, carrying out local venue distribution to provide real-time information to Commentators as well as forwarding data to central systems for additional processing. Those central systems published results for use by the media on an intranet and extranet, provided printed reports for distribution to the media and distributed the Olympic Data Feed for use by the Games-time website, press agencies, broadcasters, International Federations and others to carry out their own processing of the comprehensive set of results and related information</p> <p>A range of critical Games-time operational applications, for example, Accreditation which managed the production of Accreditation passes for Olympic Family, Athletes, Workforce and media to enable access control for specific areas of the venue.</p>

Continued

**Table 1** *Continued*

Office Admin	The LOCOG corporate network which supported the organisation during the years leading up to the Games and also provided many important Games time applications developed by the Organising Committee, often specific to the particular functional area (department)
Core Network	The underlying data network that supported the Competition and Non-Competition venues.
<ul style="list-style-type: none"> <li>• Internet Access</li> <li>• Telephony</li> <li>• Community Area Television</li> <li>• Rate Card Services</li> </ul>	<p>Provided wired and wireless internet access, primarily for members of the media</p> <p>Fixed line telephones distributed across the competition and non-competition venues, along with a range of associated services.</p> <p>Video feeds distributed within competition and selected non-competition venues that used either locally generated content and/or channels made available from the International Broadcast Centre</p> <p>A range of network services that were purchased by press, broadcast and other organisations</p> <p>For further details of the network and the services it provided please refer to the IET publication, <i>Delivering London 2012: ICT Enabling the Games</i> ISSN 978-1-84919-568-3; <a href="http://www.theiet.org/ict2012">www.theiet.org/ict2012</a>:</p> <ul style="list-style-type: none"> <li>• BT Communication Services enabling the Games</li> <li>• Openreach super-fast fibre and the London 2012 Olympics and Paralympic Games</li> </ul>
Ticketing	Systems at competition venues for ticket checking, queries and box office
Audio-Visual & Public Announcement Systems	The wide range of different audio-visual and public announcement systems used at venues
Private Mobile Radio	Private mobile radio service deployed to primarily support handheld radios used by the workforce and other key groups
Mobile Telephony & Data	Enhanced mobile telephony and data services required for Olympic Family and also for public use. For further details of the network and the services it provided please refer to the IET publication, <i>Delivering London 2012: ICT Enabling the Games</i> ISSN 978-1-84919-568-3, <a href="http://www.theiet.org/ict2012">www.theiet.org/ict2012</a> :
Hosted Services	<p>Hosting of London2012.com and the many associated websites.</p> <p>For further details of the London2012.com website please refer to the IET publication, <i>Delivering London 2012: ICT Enabling the Games</i> ISSN 978-1-84919-568-3; <a href="http://www.theiet.org/ict2012">www.theiet.org/ict2012</a>:</p> <ul style="list-style-type: none"> <li>• Developing the London 2012 Games time website</li> </ul>

The London2012.com website was stressed by the level of demand early in the Olympic Games and, co-ordinated by the TOC, a number of changes were implemented to ensure that it would cope when the most high profile events started, such as athletics. In advance of the Games, the site had been load tested extensively, including a simulation of 1 million concurrent users; however, a number of factors such as differences in user behaviour

caused higher than expected load on the data centre infrastructure. The immediate and pre-planned response to this situation was to increase the Time-To-Live settings for website content caching, increasing the time before new content such as live results would be available to the users. This was a temporary step, enabling optimisation of content plus overnight improvements on server and storage platforms – although this overnight work still had to take



**Figure 2** *Technology Operations Centre*

place without interrupting the more than 170k users on the site.

## 2 Standardisation

As highlighted in the original publication, standardisation was fundamental to delivering technology for the Olympic and Paralympic Games. With tight delivery and implementation timescales it was essential to deploy proven solutions in the venues that would just work and were known to be robust and tested, as any time spent on troubleshooting at that stage was a threat to readiness. The standardisation included high-level venue classifications, whereby each venue was classed according to the required services and service levels, which then dictated which of the template network design should be applied, but this extended right down to the specific hardware/software configuration combination for PCs, printers and other components.

## 3 Security

Significant attention was paid to security across the full extent of Technology and whilst the original publication provided no more than a passing reference as this was a very sensitive topic, more details are now provided in the section on Cyber Security and Resilience. Without a doubt, the focus on this area was necessary and justified: the website *was* the prime target it was always expected to be, but the security controls put in place enabled the attacks to largely take place in the background with minimal effort necessary from the TOC.

An important point that this publication can clarify is the meaning of the security statistics issued after any Olympic Games. For example, it has frequently been quoted in the media that ‘The Beijing Olympics saw 12 million cyber security incidents during their Olympics’ [Simulated cyber attacks for 2012 Olympic computers <http://www.governmenttechnology.co.uk/gt-news/item/2692-simulated-cyber-attacks-for-2012-olympic-computers>]. For London 2012, the security event management systems gathered event messages from many different components across the network and server estates. These messages were processed and correlated to try and identify ‘potential’ security events that were then flagged for analysis by the security operations team. The numbers of messages coming into such systems were huge – 2 billion in one example from the Cyber Security and Resilience paper – but the vast majority were completely innocuous and included user login errors, normal firewall activity and so on. The security-related events identified out of these messages are a measure of the sensitivity of the event monitoring system, and these plus incidents logged through other routes such as the service desk reflect the actual workload on the security operations team during the Games.

In addition to the LOCOG content, the publication also includes information provided by the BBC covering the use of wireless technology, online and broadcast content, Super High Vision plus the Spectator Journey Planner application developed by Atos for public use and delivered in partnership with the Olympic Delivery Authority and transport authorities.



# Paper 2 – Wireless and Mobile Technologies: Overview and Introduction

*David Finch*

Senior Manager, Architecture and Security, LOCOG  
<http://uk.linkedin.com/pub/david-finch/2/a21/361/>

Of all the technologies deployed for the London 2012 Games, those services with a dependency on radio frequency (RF) communications required the most attention in order to ensure that they could operate successfully together and within the pre-existing environment without interference or conflict. Whilst many RF-based services were deployed directly to support the Games, they of course could not be used at the expense of other critical services, such as those supporting emergency services or in everyday use by the public.

The most significant and critical services deployed by LOCOG that needed to seamlessly fit into the existing RF landscape included:

- Timing and Scoring

Use of RF varied by sport and the degree of difficulty depended on whether the particular system used licenced or licenced-exempt spectrum. However, it was a significant dependency for Sailing and outdoor road races as well as being used in contact sports such as Fencing and Taekwondo.

- Wireless Internet

Services were provided for various client groups, including chargeable rate card Wi-Fi for the media, BT Openzone for public use, free Wi-Fi for Athletes and Olympic Family plus dedicated operational services for ticket scanning and access control.

- Private Mobile Radio

Comprised of more than 21 000 radios for use by the LOCOG workforce, including Games Makers.

- Mobile Telephony

Services for public use, with additional enhancement for specific locations accessed by Olympic Family.

In addition to the above, a vast array of radio-based equipment was also brought in for the Games, primarily by the media, with a significant proportion from overseas and conforming to varying regulatory standards. This equipment ranged from Wi-Fi routers and telephony systems through to wireless microphones, cameras and satellite dishes installed at the International Broadcast Centre to provide uplinks to home countries. The now ubiquitous Smartphones carried by a high percentage of people attending the Games, not just the thousands of spectators, of course added to the background of RF activity.

With this environment of many disparate wireless systems operating in close proximity, RF coordination was essential. Ofcom worked closely with LOCOG to provide spectrum management, with the aim of prioritising the LOCOG Games-critical services, minimising interference issues with existing RF users and avoiding conflict between the different client groups trying to operate the systems they needed whilst at the Games. However, with so many potential sources of radio interference, even including microwave ovens or unknown faulty electrical equipment, it was of course impossible to provide absolute guarantees as to the availability of radio spectrum; therefore contingency plans were available to mitigate the risks to critical services, for example, wires instead of transponders to connect fencers to the scoring system (Fig. 1).



**Figure 1** *Fencing at the ExCel*

For the Wi-Fi services, a more granular scheme was necessary for use of the 2.4 and 5 GHz ranges shared by Wireless Local Area Network (WLAN) equipment. In general, BT minimised their use of 5 GHz channels and operated within a range of reserved 2.4 GHz channels. For other organisations wishing to set up their own Wi-Fi network within the Olympic domain, it was mandatory to formally request authorisation from LOCOG, whereupon they would be provided with a specific channel allocation and service set identifier to configure; restrictions were also imposed on radiated power and use of 802.11b was prohibited because of the performance degradation it causes in a mixed client environment. This scheme was not without difficulty, there were the typical interference challenges of operating in a licenced-exempt spectrum, technical issues with third-party equipment not supporting a required configuration, nuances in the Wi-Fi standards for equipment from different countries plus other more unusual issues: in one case, a media organisation needed help because they lacked the necessary technical skills to configure their equipment, but the LOCOG support team found it difficult to assist because of the language used in the user interface and in the product manuals.

The expectations surrounding Wi-Fi leading up to the Games were extremely high, with discussions in the press about what would be provided long before specific plans were put in place. Ultimately, Wi-Fi services met expectations with the deployment of BT Openzone for the public plus various specific services deployed for other client groups. However, for the Rate Card Internet service,

LOCOG and BT agreed early on that this should be 'wired' as far as possible, making it more realistic to guarantee that the strict service level requirements could be met: this was an absolutely critical service for the press, allowing stories to be uploaded directly from the seated press tribunes and images to be uploaded from photo positions by the field of play. In other locations, such as media conference rooms, it was only realistic to provide a wireless service for the media; for ease of use this was made as consistent as possible with the wired service by using a common user interface and user authentication solution.

In terms of mobile telephony, it would have been inappropriate for a single operator to have a monopoly on services for the public and it would also have been challenging for a single operator to provide sufficient capacity across many venues. Therefore the approach taken was for the major UK Mobile Network Operators to work together as part of the Joint Olympic Operators Group in order to share costs of the infrastructure and ensure that their customers could universally receive good levels of service. Beyond this however, Olympic Family users including LOCOG workforce required mobile access in 'Back of House' areas of the venues, beyond the range of public service. Enhanced coverage was achieved in these locations using dedicated infrastructure from O2 with corresponding SIM (Subscriber Identity Module) cards and Samsung-sponsored mobile telephones: the latter included the Galaxy range of Smartphones with a custom-developed connection manager to automatically use the LOCOG Wi-Fi service when in range.



# Paper 2A – Spectrum Management at the London 2012 Games

*Peter Bury*

*Spectrum Policy Director, London 2012, Ofcom  
E-mail: Peter.bury@ofcom.org.uk*

## 1 Scope

As part of its bid for the Games the UK Government committed to the International Olympic Committee (IOC) the allocation of the frequencies required for organisation of the Games and waiving of fees payable for the allocated frequencies. Ofcom was responsible for delivering these guarantees; and also for managing the integrity of the radio spectrum at Games time. In parallel, Ofcom had to meet the needs of non-Olympic Family spectrum users, such as non-accredited media, the performances of the Cultural Olympiad and the transport and security services, whose functions were essential to the overall success of the Games. Over 30,000 technical frequency assignments were needed to accommodate the radio frequency (RF) needs associated with the Games.

London is one of the most densely populated radio environments in the world and meeting all these RF requirements represented a major challenge. Ofcom undertook a five-year programme of work to:

- estimate likely demand
- source suitable spectrum
- maximise the capacity and re-use of the spectrum
- match users' requirements to available spectrum and issue licences
- test radio equipment for conformance
- respond to reports of interference at Games time.

## 2 Spectrum Plan for the Games

Ofcom commissioned research into the likely demand for spectrum resources and took account of demand at the

Beijing 2008 Games. On this basis, and in the light of the spectrum resources, which could be made available by public-sector users and others, Ofcom developed, and widely consulted on, a Spectrum Plan for the London Games. In October 2009, Ofcom published a Statement setting out the spectrum plan for wireless communication at the Games. An update to this statement was issued in October 2010, and a further statement on 2.6 GHz in December 2010 which completed the Plan. Ofcom published final confirmation of the Plan in February 2012. [All these documents are at <http://stakeholders.ofcom.org.uk/spectrum/olympics/>]

The Spectrum Plan set out the frequency bands available to the Games and encouraged spectrum users to adapt their requirements to match the available spectrum. Bands conventionally used for Programme Making and Special Events (PMSE) purposes were used as far as possible while maintaining access for the normal business users (recognising that they too were likely to have increased demand during the London 2012 Festival).

In meeting the very substantial additional demand, the Plan benefited from the availability of the ultra-high frequency (UHF) spectrum released by the closure of analogue television (TV) services in London in April 2012. This was used for wireless microphones, in ear monitors (IEM) and the wireless community access television service (a service offered by Olympic Broadcasting Services, which provided continuous live video streams of Games coverage to handheld receivers in the venues). The London Games was also fortunate in the availability of spectrum between 2.5 and 2.69 GHz, which is being prepared for auction in Q1 2013. This was used for wireless cameras at the Games.

Further spectrum resources needed to support the Games were sourced from public sector users who were able to

rearrange operations, training and exercising activities to grant access to spectrum during the Games; and from commercial users who were able to co-ordinate their usage with the requirements of the Games.

Examples of demand for and occupancy of key frequency bands used for the Games are set out in Figs. 1 and 2. These show the number of available channels and the number of assignments (an 'assignment' is a channel at a location at a time) made in some of the most popular bands for PMSE – wireless cameras and video links above 1 GHz; and private mobile radio, talkback and telemetry systems in very high frequency (VHF) and UHF. Demand is focussed on bands such as 1.9–2.7 and 450–470 MHz where equipment is most readily available.

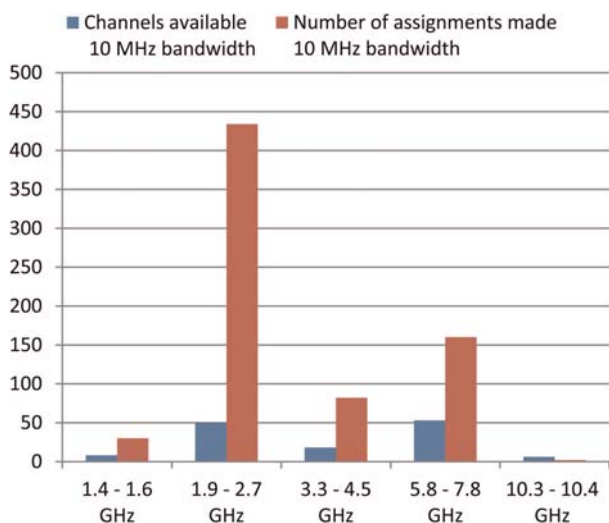


Figure 1 Video link usage above 1 GHz

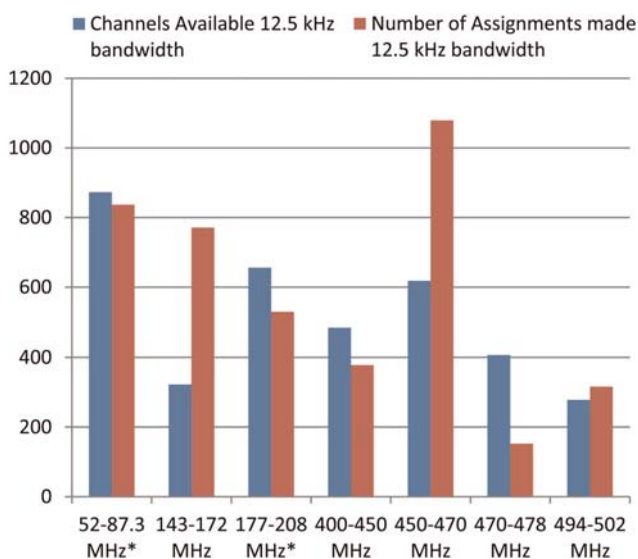


Figure 2 Communications usage in selected VHF and UHF bands

### 3 Maximising capacity and reuse

While it was fortunate that additional spectrum was available to London in 2012, the high level of demand meant that this had to be utilised as efficiently as possible. Ofcom used predictive modelling to maximise the opportunity for reuse between different users and uses (both Olympic and other) of each band while ensuring appropriate quality of service was maintained for all. Where necessary, Ofcom supported computer modelling with field measurement: this proved particularly important for very congested bands (such as UHF and the 2 GHz wireless camera bands) where we were also able to test co-channel reuse between specific key systems in the lead up to the Games.

Broadcast support applications such as radio microphones and IEM systems generally operate in the UHF Television bands (470–862 MHz), utilising the 'white space' in the local television coverage map. This white space, along with the spectrum cleared as a result of digital switchover, was heavily utilised during the Games. In London, for example, assignments were made in 248.3 MHz of spectrum (equivalent to 31 TV channels).

Some channels proved extremely popular with stakeholders because of the popularity of certain tuning ranges in equipment. In order to accommodate this demand, we had to reuse frequencies in different locations, taking into account the layout of venues and the impact of different building characteristics on RF propagation. As an example of the level of 'packing' achieved, the 8-MHz TV channel 42 accommodated 26 microphone assignments at the IBC – compared with our original estimate of only 14 microphones per TV channel within a single venue.

The tools Ofcom used for planning assignments at the Games were extensions to its Spectrum Management System. These were designed to optimise assignment patterns, ensure efficient coordination between use inside and outside venues and to avoid intermodulation, which is a potential cause of interference and is particularly important where a large number of systems are co-located.

In addition, Ofcom conducted an extensive measurement 'audit' of actual usage in each of the bands planned for the Games, using the network of wireless sensors in the venues and elsewhere.

### 4 Services

Ofcom defined 13 services for licencing. The total number of licences [In some cases separate licences were issued for Ceremonies, Olympic and Paralympic Games.] issued and frequency assignments [Duplex pairs counted as two frequency assignments.] made for the Games period is in Fig. 3.

Product	Licences	Assignments
Wireless Camera	452	631
Wireless Microphone	1958	6052
Talkback	946	3037
Land Mobile Radio	1412	3026
Telemetry and Telecommand	331	444
In Ear Monitor	496	1468
Maritime Mobile Radio	18	44
Microwave Mobile Link	114	133
Fixed Link	76	90
Permanent Earth Station	20	n/a
Transportable Earth Station	28	1439
WCATV	4	5
Games PMR Network (Apollo)	1	206
Total Games	5861	16576
Outside venue clearances in coordination zones	n/a	13237
<b>Total Frequencies Licensed</b>		<b>29813</b>

**Figure 3** Licences issued and assignments made to Games users

## 5 Licence assignment process

End users registered their requirements through LOCOG, providing details of the services they needed, the location(s) of their installation, the technical parameters of their equipment and the duration of their requirement. Ofcom matched these requirements with the available spectrum and issued appropriate wireless licences to users. In practice, user requirements and spectrum plans evolved iteratively through a discussion between stakeholders, LOCOG and Ofcom. These discussions helped establish the nature and criticality of requirements, as this was often material to the final spectrum arrangement for particular systems.

Over 6000 licences were issued to more than 250 organisations occupying over 1 GHz of spectrum. 17,000 assignments were within the Games venues and 13,000 for applications outside the venues.

An example of the complexity of the licencing process was in providing coverage of cycling and other road races. This involved assigning frequencies for high-power video links for TV coverage from the air, with their associated talkback and telemetry services. These links were essential to broadcasters' coverage of the events and had to be resilient against interference and co-ordinated with other wireless camera use on the ground.

## 6 Equipment inspection

All items of wireless equipment were required to have a 'tag' to enter the Games venues. The tag confirmed that the equipment had been inspected by Ofcom engineers for compliance with the details of its associated licence. Equipment was checked with a portable spectrum analyser for conformity with the frequency and occupied bandwidth

specified in its licence; and for any spurious emissions. Major wireless users were certified against batch sampling or certified to test and tag their own equipment. Ofcom conducted 8000 tests itself and issued 60,000 tags.

In addition to testing portable equipment, Ofcom also encouraged users to meet best practices in site engineering and rigging when making their fixed wireless installations. All recipients of wireless licences were issued with a guide to technical best practice in RF engineering (<http://stakeholders.ofcom.org.uk/binaries/spectrum/olympics/Eng-Code-of-Practice.pdf>). Nevertheless a significant proportion of the cases, which were reported as interference at Games time were diagnosed as being the result of faulty equipment or incorrect installation practice.

## 7 Spectrum monitoring and direction-finding

Ofcom deployed a network of remote receiving equipment for spectrum monitoring and direction-finding. The components of this network were:

- Nine Angle of Arrival (AOA) based receivers on trailers which could be re-located when necessary. These were primarily used for direction-finding where interference was reported. They were particularly suitable for detecting narrowband and unmodulated signals.
- Sixty-Seven Time Difference of Arrival (TDOA) based sensors which were installed in fixed locations within Games venues and at other key locations. They were used for spectrum monitoring and data gathering across a wide range of frequencies; and for geo-locating emissions. They

were particularly suitable for locating the source of wideband modulated signals.

- The teams of field engineers deployed in venues to respond to interference reports were equipped with handheld spectrum analysers and directional antennas. They were an essential tool in pinpointing the characteristics and source of potentially interfering signals.
- The monitoring network which consolidated data from the AOA receivers was hosted at Ofcom's National Monitoring Centre; while that for the TDOA receivers was hosted by a supplier.

The AOA and TDOA equipments were networked and could be remotely accessed by individual engineering staff, the LOCOG Technology Operations Centre or from Ofcom's National Management Centre at Baldock.

## 8 Incidents and incident management

Ofcom deployed a team of 120 spectrum engineering experts to respond quickly to any reports of harmful interference. These colleagues worked on shifts to cover all key times for the Games, so there were 30–40 engineers on duty at any time.

As a result of the careful technical work in preparation for the Games, the number of incidents of harmful interference was relatively low. In total, 177 cases were handled during the Olympics and 42 during the Paralympics. Most were relatively minor but a small number of cases had the potential to have a significant impact on the Games. All incidents were handled successfully and there was no significant impact on the Games from spectrum problems.

## 9 Conclusions and lessons learned

The London 2012 Games placed a heavy burden on the spectrum resources of the UK. A collaborative approach from a wide range of public and private sector spectrum users made it possible to find enough spectrum resources; and careful technical planning made it possible to use these frequency bands to meet the additional needs of all users during the Games. The UK Government's guarantees of spectrum availability were fully met.

This careful preparation of the assignments, together with extensive monitoring and equipment inspection in advance, limited the incidence of harmful interference during the Games. Those problems that did occur were quickly resolved by the field engineering team, including those which were the result of faulty equipment or incorrect RF engineering.



# Paper 2B – Wireless and Spectrum: The BBC Perspective

*Alex Russell*

*Senior Commercial Manager, BBC Distribution  
E-mail: Alex.Russell@bbc.co.uk*

The BBC had over 1500 wireless devices in use during the Games making the corporation one of the largest users of this spectrum.

Overall, the organisers did an excellent job of dividing up the available bands and policing their use at the venues. Key to this were London Organising Committee of the Olympic and Paralympic Games (LOCOG) and OFCOM's spectrum teams, which were made up of people with a very high degree of engineering expertise. They were able to engage with us two and a half years out and came with a working knowledge of the equipment likely to be used and the frequency ranges within which that equipment operated. This enabled the broadcasters to avoid significant cost from refitting existing cameras with alternative wireless modules.

Important to pulling together a solution which worked for us were the test events. These served as a great proving ground for LOCOG's spectrum plans. Generally speaking, the BBC uses standard frequencies for outside broadcasts which were different from those assigned for venues by LOCOG. The test events proved a good way to educate other parts of the organisation on the agreed frequency allocation for Olympic venues. This meant that people and equipment arriving during the few weeks of the Games were likely to come properly prepared.

One very significant decision was that the BBC's existing UK spectrum licences were allowed to continue during the Games, this is one of the benefits of being a home broadcaster and made things simpler. However, we were required to apply for spectrum licences for almost all equipment that transmitted. Notably, radio microphones, in ear monitors, talkback base stations and mobile units, radio cameras, telemetry control for cameras, fixed links,

satellite uplinks and for the first time ever Wi-Fi units. This was across all BBC users, operating inside Olympic venues, a complex task, with requirements from News, Radio, Sport, Nations and Regions and Online/web comprising approximately 700 staff.

The most challenging area was around the Olympic Park where each venue was its own licenced zone. LOCOG managed these areas well and through detailed planning was able to minimise interference between venues.

One significant compromise we had to make was with the use of wireless cameras. We were not able to obtain suitable frequencies for a camera to have the desired flexibility both inside and outside a venue. The most obvious drawback was that we could not carry a single shot of an athlete from outside all the way through to the stadium. In addition, it also meant that there was no option to quickly redeploy an exterior camera if the production required it. In order to cope with this some editorial aspirations were modified and coverage was provided by mixing radio cameras with some existing static cameras and finding alternative ways of providing reduced coverage, without too much impact on the resulting experience for the viewer.

Another big problem in the run up to the Games was access to venue Wi-Fi. The requirement broadcasters had to use Wi-Fi in venues with line-of-site to the field of play which was not incorporated initially. This was possibly because of concerns about use for high bandwidth applications such as video upload or large photo transfers. However, our organisation like many others made significant use of blogging and tweeting to report Games action, both of which require low bandwidth network

---

access. It was unclear until quite late on in the BBC's planning whether this would be available.

The key lesson here is around the importance of planning access to Wi-Fi as a normally licence exempt area of spectrum in a co-ordinated (cross-organisational) way.

The level of thought and time paid to spectrum concerns at this Olympics was unprecedented and that certainly benefited the BBC and the Games hugely.



# Paper 2C – London 2012 – review of the Olympic Family Mobile Service and public mobile performance during the Games

*Steve Hurdle*

*Mobile Programme Director, BT London 2012 Programme  
E-mail: steve.hurdle@bt.com*

## 1 Overview

Smartphone and Tablet devices have become game changers for Mobile Network Operators (MNOs), the rapid development in speed, capability and market penetration of these devices have created enormous incremental public demand for data services, which has at times stretched MNO networks to the limit. As a result, mobile services were critical to the success of the Games with mobile data a 'must have' for all users and many of the events being followed globally on Twitter and Facebook. Even though high-capacity Wi-Fi and fixed data points were abundantly available, the overall Olympic demand for 2G and 3G mobile data was unprecedented.

MNOs responded by committing significant investment and huge efforts to uplift capacity at key locations for the London Games with more mobile coverage and capacity provided for the London Olympic Games venues than for any other Games in history. As part of this investment, BT provided London Organising Committee of the Olympic and Paralympic Games (LOCOG) with a dedicated Olympic Family Mobile Service (OFMS) in over 30 key venues to support LOCOG operational services. This service was delivered using coverage extensions to O2's public services.

BT also specified and optimised a customised Wi-Fi application for all LOCOG devices; this was developed by Wireless Communications Equipment partner Samsung to deliver wireless broadband data performance for LOCOG VIP users in Olympic venues and hence complement the dedicated cellular mobile coverage. Over 19,000 custom BT

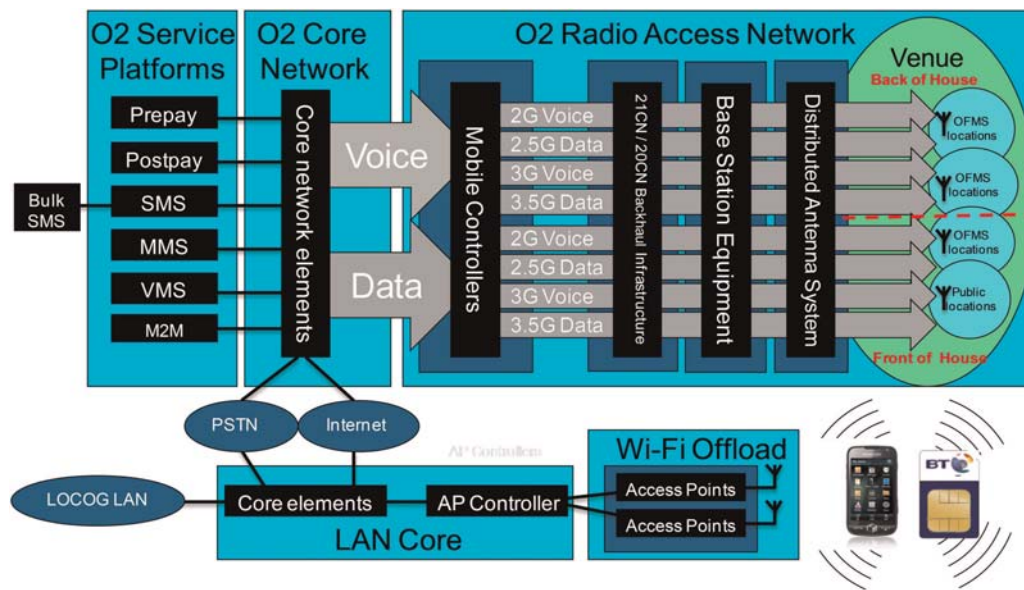
London 2012 branded SIM cards were provided for LOCOG users and Olympic family customers.

## 2 Technical infrastructure

Dedicated mobile infrastructure was provided by BT to enhance mobile coverage and capacity at venues specified by LOCOG, known as 'Essential High' venues, such as competition venues and critical operational locations. BT also supplied over 19,000 SIM cards and mobile airtime accounts for mobile handsets provided by Samsung for the Olympic family and for customers who brought their own devices.

In the 'Essential High' venues, enhanced coverage (the OFMS service) was provided for operational back-of-house areas, that is, areas not accessible by the public such as the Olympic Family Lounges and key operational locations, and for VIP seating areas in the stadia seating bowls. BT contracted O2 as its mobile partner to provide the SIMs and this dedicated OFMS infrastructure, illustrated in Fig. 1.

Public services in front-of-house areas from all MNOs were co-ordinated and controlled by the Joint Olympic Operators Group (JOOG), comprising Telefonica O2, Vodafone, Everything Everywhere and 3UK. Their investments in Public mobile infrastructure installations were shared and completed at over 50 new venue systems and base station cell sites on the Olympic Park and at other key Olympic venues (e.g. Weymouth, Greenwich Park, Horse Guards Parade). Mobile Network Operators (MNOs) also independently provided significant additional



**Figure 1** OFMS platform and topology

capacity and base stations locations across the capital and throughout the UK to cope with the huge additional load expected from athletes and visitors to the Games.

The Olympic Park presented UK mobile network operators with a unique challenge for a number of reasons. There was competition for space on the Park with applications for space on the ground and on rooftops being rejected and delayed owing to other priorities. There was also limited equipment cabinet space within the Olympic Park venues, which meant equipment cabinets for Front of House areas had to be located remotely and were connected to antennas using a BT fibre network.

As a result, the JOOG built a state-of-the-art shared building to house all operators' mobile technical base station equipment (known as the BTS Hotel) on the Olympic Park, which provided resilient high speed and capacity fibre connections and base station equipment for all Park competition venues, the Athletes Village, International Broadcast Centre (IBC) and the Main Press Centre (MPC). The JOOG installed the highest density mobile stadium system ever built in the UK in the Olympic Stadium, using 46 mobile sectors, which was the highest technical capability possible today for the 80,000 spectators. For further details of the Mobile Infrastructure Technology please refer to the IET publication, *Delivering London 2012: ICT Enabling the Games* ISSN 978-1-84919-568-3; [www.theiet.org/ict2012](http://www.theiet.org/ict2012): Meeting the Mobile data demand.

BT also provided an extensive high-density public Wi-Fi network across the Olympic Park and within the main sporting competition stadia. This is the largest high definition Wi-Fi network so far built anywhere in the world, providing wireless broadband speed connections

complementing the 3G cellular data networks. This took pressure off the 3G network by allowing operators to off-load data traffic onto Wi-Fi.

All other venues and areas were served by public domain mobile services (e.g. Hilton Hotel Mayfair and Lords Cricket Ground).

In all cases, BT provided JOOG Mobile Operator teams with a priority assisted venue access process for engineers to ensure that network issues and associated testing requirements were dealt with in a controlled and efficient manner.

### 3 User experience management

One of the key challenges was managing customer expectations of service where the public services of O2 had not been enhanced in terms of either reach or footprint. For example, the Hilton Hotel on Park Lane was not provided with enhanced coverage yet was home to many IOC officials. Service for those customers at the Hilton was affected throughout the Games by the capacity demands of the general public at the Hyde Park London Live concerts. This was essentially a public mobile service issue and not OFMS specific, so BT worked with O2 to improve the situation in balancing capacity and network configurations to improve the service as far as possible.

Even where services had been enhanced, there were still expectations to be managed around the reliability of calls. The BT team frequently had to explain that although the success rate of mobile calls was extremely and consistently high across the OFMS estate, dropped calls could still occur for many reasons. For example, if the customer is in an area of limited coverage such as a lift, a stairwell, store

room or lavatory then calls can drop-out if the customer passed through these areas or moved between cellular cell boundaries.

In conclusion, no public radio service can provide 100% coverage or capacity; therefore some in-call failures are characteristic of the service. For this Olympics, the call success rate was very high even compared with much smaller sporting or special events, the mobile networks performed excellently and the success of the technology has been widely reported in the UK media.

## 4 Performance during the Games

The construction and fit-out of stadia for major events are always challenging to manage, and therefore it was no surprise to BT that there was late availability of venue access and delay to consents to erect mobile temporary masts. This meant that the critical initial optimisation process had far less time than was planned, and hence on the Olympic Park, dropped call rates were initially marginally higher than expected. This was quickly remedied through network optimisation. The final optimisation in the unique context of the Olympic Park (a large area of brand new development with unprecedented mobile coverage density) required exercising a real service 'load' (a meaningful number of several tens of thousands of people using their mobile phones for voice, data and text services). The lack of full-load testing meant that the first real opportunity for load testing was at the opening ceremony rehearsals, literally a few days before the opening ceremony itself.

Prior to the Games, there were public concerns whether the mobile networks could meet the demands of the opening ceremony and the full load of visitors to the Olympic Park (250,000 on peak days). In practice, the mobile networks dealt with the opening ceremony and through skilled optimisation work, continuously improved performance day after day. On 'super Saturday' 4<sup>th</sup> August, to assess the customer experience, one of the BT on-Park support team streamed the entire Team GB football game whilst watching the Athletics events at the main Stadium. It is a massive testament to the performance of the mobile and Wi-Fi networks that a stadium full to capacity with a crowd of 80,000 can boast that level of data capability. The public demands on such services, in particular mobile data, continue to exceed forecasts and this must be an essential requirement for Major Events in the future.

Whilst there was anecdotal reporting of issues with the Olympic Family Mobile Services there was little evidence that problems persisted at levels any higher than in the external public mobile networks. Issues investigated and acted upon included:

- Reported dropped calls in the Olympic Stadium and across the Olympic Park were addressed by post opening ceremony optimisation. Detailed analysis by O2 for the dedicated OFMS infrastructure showed that 99% of the 7000+ calls made during the event were successfully carried on the night of the opening ceremony.

- Capacity issues were reported for the public at Eton Dorney. Network optimisation was carried out after the first 'load test' (day 1 of competition) and the issues were rapidly resolved.

- Road Race broadcaster information on 28 July was affected by the high levels of public utilisation in rural areas of the race route with reportedly over 1,000,000 people lining the route sending tweets, Facebook and photo uploads. For the subsequent Walking and Marathon race events BT assisted Omega and LOCOG by deploying fixed broadband services and mobile backup connections to provide higher resilience. The ability to be responsive in such situations is critical, and was a driving factor in ensuring that there was flexibility built in to both the infrastructure services as well as the operational support model surrounding them.

## 5 Mobile reporting

BT provided daily reporting on mobile infrastructure availability to LOCOG, demonstrating that the service was stabilised and was exceeding SLAs. These reports monitored call success rates on 2G and 3G in the Olympic Park itself on a daily basis covering JOOG and public infrastructure as well as Essential High infrastructure.

Statistics were also produced on OFMS usage, with a peak hour figure of about 8000 calls being carried on the service, 65% of which were on 3G.

Where users expressed concerns about the level of service they were receiving, then additionally their individual mobile service could be tracked by O2. Tracking was over a 24 hour period and included usage in and out of Olympic venues.

## 6 Conclusions

Overall, the services were a major success. In the Olympic Park, an estimated 250,000 visitors each day enjoyed excellent mobile coverage provided by all UK MNOs. Within the Olympic Park, OFMS and O2 customers sent or received 35,000 texts, 38,000 calls each hour during peak hours, together with 450 GB of data per day. The OFMS service itself recorded 100% uptime and no Severity 1 service affecting failures throughout the Games Time period.



# Paper 2D – London 2012 Wi-Fi – delivering the best connected Games

*Eddie Green*

*BT Mobile and Wi-Fi TDA, BT London 2012 Programme  
E-mail: eddie.5.green@bt.com*

In the 4 years which separated the Beijing 2008 Games from the London 2012 Games, people's use of technology was revolutionised by the rapid and widespread uptake of smartphone devices and tablets, indeed the iPad was not even available in 2008. The emergence of an 'always on line' society fuelled by services such as Facebook, Twitter and You Tube demanded that London 2012 be the best connected Games ever. As the official communications provider of the Games, BT, working with the infrastructure partner Cisco, took on the challenge by delivering the largest single implementation of high-density wireless network capacity ever seen in the World. A key element of this was the provision of a widespread high capacity Wi-Fi network designed to support the needs of both the Olympic Family and the visiting public. Requirements and expectations for Wi-Fi were high given its wide availability on modern devices which would be used by just about every community involved in the Games. These ranged from the Press, Broadcasters, VIPs, Athletes and Operational staff, to the visiting public and led to a wide and varied set of service requirements which had to be supported by the design.

Wi-Fi protocols are not ideally suited to delivering high-capacity solutions and, given their reliance on the licenced-exempt ISM spectrum, present a major challenge when trying to design for the likely demands of the always on-line generation. Analysis quickly showed that the standard Wi-Fi design, typically used in large installations, would not be capable of serving the expected data demands because of radio interface limitations. It was clear that a new approach known as High Density (HD) Wi-Fi had to be taken. BT worked with London Organising Committee of the Olympic and Paralympic Games (LOCOG) and Cisco to deliver what became the largest single implementation of HD Wi-Fi access points in the World. Spectrum and interference issues also demanded that a

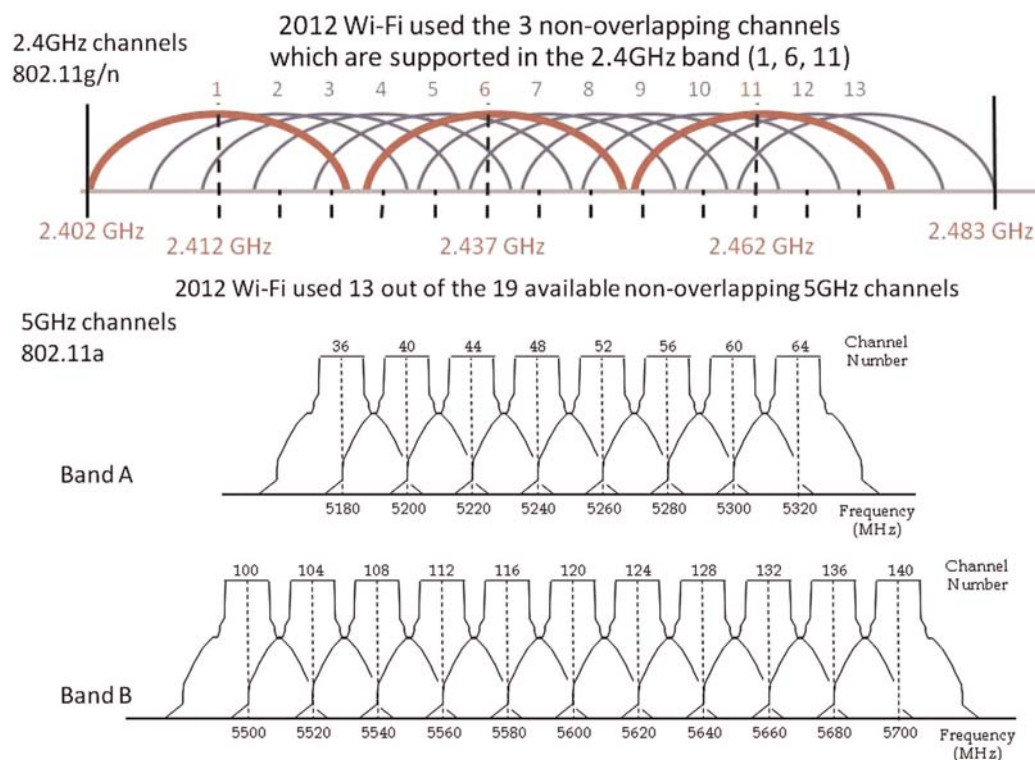
harmonised solution be used which would support all London 2012 Wi-Fi services on a single platform. Owing to the uniqueness of the task, major challenges existed in all project phases but this was successfully completed to a very challenging timeline.

The Games saw the BT Wi-Fi network support record levels of users together with a consistently high user experience, with users who had devices which used the 5 GHz Wi-Fi band able to continuously stream live video within the Olympic Park venues. Users with devices, which could only use the 2.4 GHz Wi-Fi band did at times have a poorer experience in the larger venues, that is, the Olympic Stadium, due to 3rd party interference, which existed in this licenced-exempt band. Whilst BT and LOCOG made strenuous efforts to remove and manage these interfering sources, the volumes involved made this extremely difficult and hence this 'older' technology was inherently limited.

## 1 London 2012 Wi-Fi landscape

The vast majority of Wi-Fi capable devices rely on the 2.4 GHz Industrial, Scientific and Medical License-Exempt Spectrum usage (ISM) band, which only has three non-overlapping channels as shown in Fig. 1. Various demand predictions, fuelled by expectations of easy access to live streamed content, led to concerns about whether the Wi-Fi radio interface had sufficient capacity. This led to the following key policy decisions being made for the 2012 Games:

- Heavy data users, such as the Press, would be encouraged to use fixed LAN access in all media work areas and tribunals
- Wi-Fi for these same users would only be provided in locations where fixed LAN connectivity was not desirable or practical, for example, Press Conference rooms



**Figure 1** Wi-Fi 2.4 GHz/5 GHz spectrum/channel plan

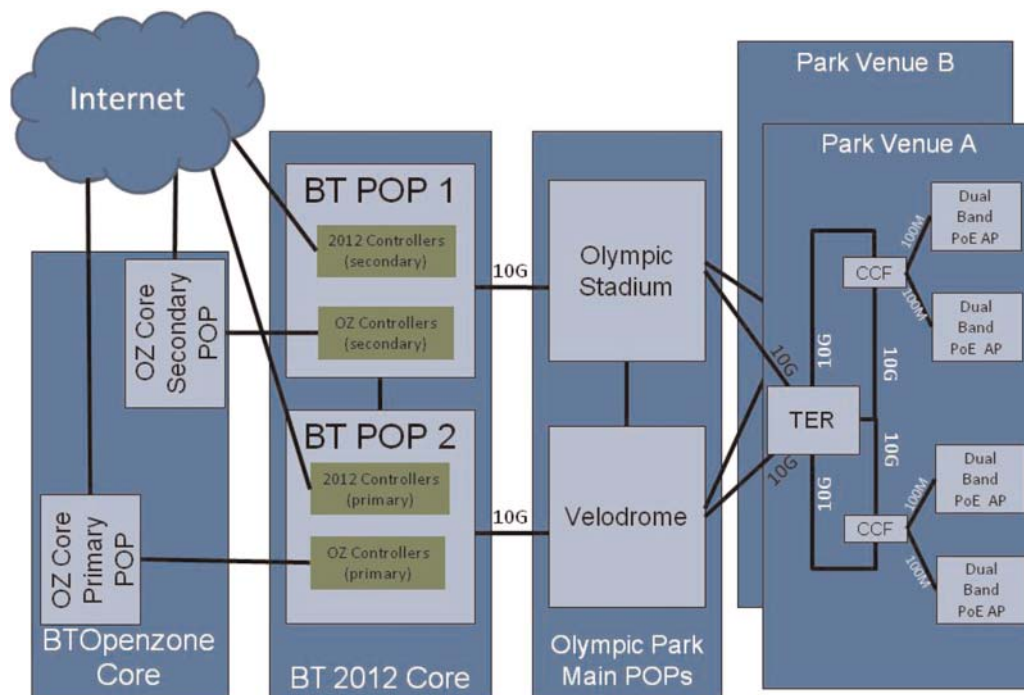
- Areas that would be subject to heavy demands would be delivered using, the relatively new, High Density (HD) Wi-Fi design principles
- All Olympic Family data capable mobile devices would support a connection manager that would pass traffic to the 5 GHz Wi-Fi band, which has many more channels, as shown in Fig. 1, and is relatively underused given that many mobile devices do not currently support it
- That no unapproved third party user of the 2.4 GHz ISM band would be allowed in the venues to ensure that a single optimised high-capacity network would be available to support all user requirements without unwanted contention or interference.
- No critical Games-time services, for example, sports systems, venue management and safety systems would use the 2.4 GHz ISM band because of its potential to suffer interference and disruption.

The Wi-Fi services delivered by BT fell into two main elements. The first was those to be delivered for the Olympic Family consisting of the VIPs, Press, Broadcasters, Athletes, Workforce and so on. The second was those provided in public areas for BT's own customers. This split was often referred to as the Olympic Family back-of-house services and the public front-of-house services. A number of Wi-Fi services were defined as detailed below to meet the requirements of a number of different user groups. Their service set identifiers (SSIDs)

were chosen carefully, with *autoconnect* at the top alphabetically to avoid address exhaustion, and names that did not identify the user group:

- *WirelessLAN*: This was a bundled internet access service [fixed + wireless local area network (WLAN)] which was available for purchase by the Olympic Family or directly provided free to the LOCOG workforce. Access was via individual username and password credentials.
- *Victory*: This was a free Wi-Fi service provided to VIPs, Athletes and associated support staff. Access was via a common pre-shared key which was directly distributed and freely advertised in VIP and Athlete areas, for example, lounges.
- *OFMSd4t4*: This was a Wi-Fi data offload service provided as part of the Olympic Family Mobile Service (OFMS) devices, which had been supplied by Samsung. All OFMS data capable devices came with an in-built connection manager, which seamlessly and transparently connected to this Wi-Fi service whenever it was in range. This helped ensure the best possible data experience in key Olympic Family locations for users of these devices. Access was via a secure pre-shared key, which had been directly built into the devices. This service was also used by security accreditation scanner devices to control access to VIP areas.
- *FanTM*: This was a closed user group service supporting 360 ticket scanning devices which were used at all Olympic





**Figure 3** *Harmonised Wi-Fi Core Design for the Olympic Park*

### 3 HD Wi-Fi venue design and delivery

HD Wi-Fi designs were used across eight Olympic Park competition venues, the common domain and in the Main Press Centre Conference room. These were the areas where demand forecasts suggested that the 2.4 GHz Wi-Fi channels would need to be heavily reused within relatively small open areas. In these areas, the following design principles were then followed:

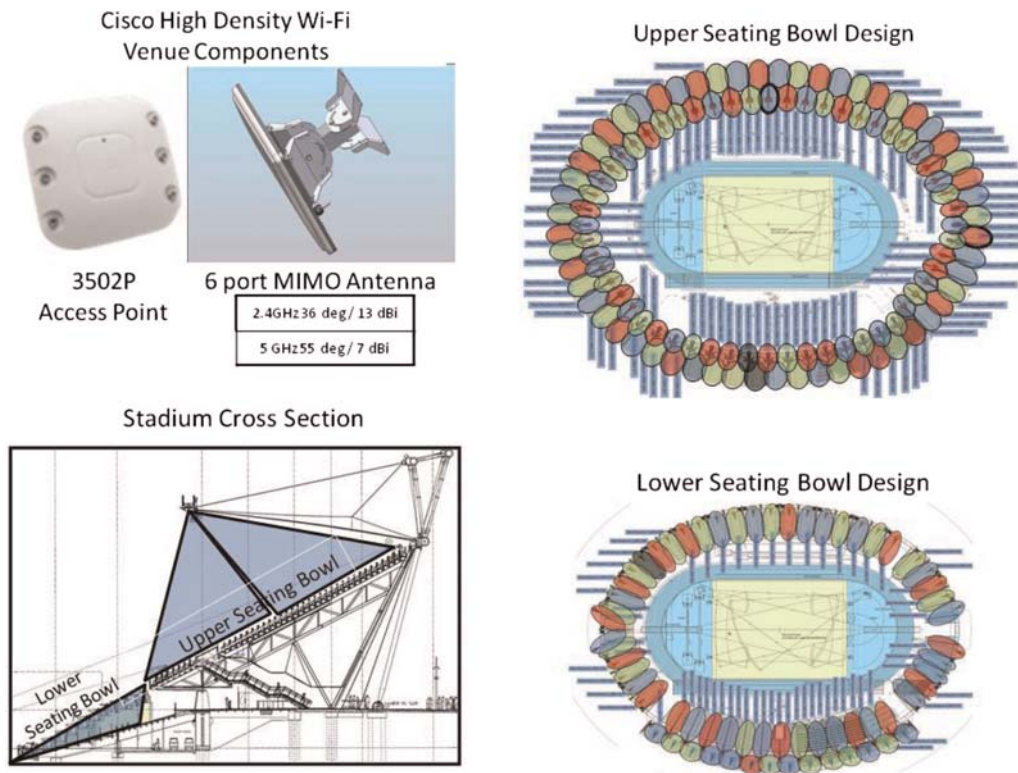
- Ensure that packets can be successfully transferred at the most efficient modulation rate possible by placing Access Points as close as to the user and ideally with a direct line-of-sight.
- Always use directional antenna to minimise interference to and from the Wi-Fi Access Points and maximise the possibility of channel reuse.
- Do not support inefficient 802.11b rates and the low end 802.11 g/a rates.
- Provide full support of 802.11 n rates and use multiple-input and multiple-output (MIMO) capable Access Points and antennas (The Cisco ‘Grayling’ six-element dual-band MIMO Patch Array Antenna was used).
- Minimise the broadcast traffic by minimising the number of supported SSIDs and reducing the beacon rate (see Fig. 4).

For a HD Wi-Fi design to work well the solution had to be installed with a precision far greater than would be required for a standard Wi-Fi installation. Validation of the

design was also crucial given that for practical reasons they had to be based on a limited and quite often constrained set of RF survey measurements. The various venue fit out activities also progressed in parallel at high pace, for example, lighting, PA and fireworks systems, leading to unexpected blockages and obstructions being placed in front of the Wi-Fi installation. The consequence was that a very comprehensive and iterative test and optimisation activity had to be completed post installation in order to ensure that the design objectives were being achieved. Typical post installation changes were as follows:

- Provision of additional Access Points, changes of existing positions, antenna tilts and orientations as required, to ensure that the coverage and local area capacity objectives were being achieved. Designing the solution in such a way as to allow flexibility for these types of changes post installation was a fundamental principle.
- Optimising the RRM settings or alternatively taking Access Points out of the automated RRM process, by fixing Access Point transmit power levels, as required to ensure that the coverage objectives were being achieved.
- Changing the antenna types as required for achieving the right balance between coverage and interference management.
- Adjusting the mandatory and supported 802.11 g/n/a data rates to achieve the right balance between cell size, error rates and throughput.

The design and delivery of these HD Wi-Fi solutions was an Olympic and UK first and the single largest HD solution



**Figure 4** Olympic Stadium HD Wi-Fi Venue Design

in the world. The test and optimisation activities were time consuming and resource intensive but were an essential requirement for the successful delivery of an HD Wi-Fi solution. Performance was proven using a number of test events in which large groups of BT people, with Wi-Fi capable devices, were invited into the Olympic Stadium in order to stress test the solution. Automated traffic generators were also used to add extra load and user experience data and network data were collected. These tests showed that web browsing worked well but that video streaming could vary significantly with device type and the level of network loading. These results were therefore used to further optimise both the physical (i.e. Access Point locations and antennae directions) and logical configurations of the high density solution.

## 4 Key challenges

The design and delivery of a relatively unproven technology, that is, HD Wi-Fi, whilst developing the skills for future capability in parallel to deploying the solution in relatively short timescales, for an event that could not slip, required that all opportunities for learning were taken.

Extensive testing ensured that the solution was capable of supporting the highest possible demands within the available spectrum. The delivery teams went through a massive and rapid learning curve. A ‘can do’ attitude combined with great team work ensured that the solution was delivered on time, despite the major challenges encountered.

During Games time, the biggest challenge was keeping the 2.4 GHz Wi-Fi channels clean by actively enforcing the spectrum policy, which had agreed to protect all approved users of the band. The reality was that the devices which use the 2.4 GHz ISM band are so endemic that huge numbers of Press, Broadcaster, Olympic Sponsors, National Olympic Committees and even LOCOG staff and their contractors brought devices onto the Olympic Park which interfered with the 2012 Wi-Fi solution. This occurred for many reasons including a lack of understanding or awareness of the communicated policy, and emphasised the need for radio planning and co-ordination to be considered in advance. The Cisco Clean Air™ solution captured interference and rogue Wi-Fi reports and were used in conjunction with the so called Wi-Fi ‘floorwalkers’ equipped to track down any interference source. Clean Air™ Interference alarms were prioritised with continuously transmitting 2.4 GHz analogue sources, for example, video senders, having the highest priority as the most damaging type of interference. At the low priority end were personal mobile Wi-Fi hotspot and tethered devices which, as a single source, had minimal impact and were anyway extremely difficult, if not impossible, to track down.

Users found to have unapproved 2.4 GHz ISM devices were either closed down, moved to alternative bands or technology options or simply encouraged to use the existing 2012 Wi-Fi. Considerable effort was spent working proactively with the press and media to help them understand the spectrum policy at the daily Press briefing provided by LOCOG and via the use of posters in key

locations around the stadiums. Active policing ahead of the sport sessions as the media arrived and completed their daily set ups provided the best outcome.

## 5 Outcomes

The Ticketmaster service worked flawlessly as did all Wi-Fi services with no customer affecting service outages occurring. The Victory service provided for VIPs, Athletes and their support staff proved a great success with aggregate usage levels matching the complete public service. It is clear that this user group come very well equipped with technology and are heavy data users.

Usage of the public Wi-Fi service was lower than expected. It is believed that this was partly due both to the success of the public mobile solutions provided by the Joint Olympic Operators Group, and partly because of the complex registration process required. The former provided significant mobile data capacity and provided a very good data experience in its own right, reducing the likelihood that users would register for Wi-Fi.

Those users with devices using the 5 GHz Wi-Fi band, as found on many Laptops, tablet and high-end smartphones,

received a superb user experience with live video streams being supported across the Park venues. Public users of the 2.4 GHz HD Wi-Fi at times had a poorer experience in the larger venues, such as the Olympic Stadium, particularly when trying to stream video. This is in line with expectations that there would be times and locations where significant levels of interference would be found in the 2.4 GHz band, which would damage the end user experience.

Larger venues were certainly hit by excessive management traffic on the radio interface, which limited the available user throughputs. This was caused by smartphone devices, which support an *ad hoc* mode and virally respond to, and then propagate without user knowledge, a 'FreePublicWi-Fi' SSID.

In general, the HD Wi-Fi solutions provided an excellent user experience across the Olympic Park. Whilst there were few negative comments around the Olympic Family Wi-Fi services, the continued rapid uptake of smartphone and tablets, which rely on Wi-Fi means that the next Olympic Games will probably require an even more extensive Wi-Fi deployment compared with London 2012.



# Paper 2E – Portable Mobile Radio solution deployed across Olympic venues and the Olympic Route Network

Michael Brogden<sup>1</sup> Russell Selwyn<sup>2</sup>

<sup>1</sup>Network Engineering Manager, Airwave

<sup>2</sup>Head of Delivery and International Operations, Airwave

E-mail: michael.brogden@airwavesolutions.co.uk, russell.selwyn@airwavesolutions.co.uk

The Apollo network, built by Airwave (see Fig. 1) for the London 2012 Olympic and Paralympic Games, was designed to meet the Private Mobile Radio (PMR) communication requirements of LOCOG. The network used Terrestrial Trunked Radio (TETRA), a digital mobile radio technology employed by a wide range of PMR users in the public safety, utilities, transport and other commercial and industry sectors.

The network solution utilised identical equipment to that used for providing critical mobile communication services to Airwave's Public Safety customers, and adopted many of the established techniques used in delivering this vital service. This proven performance, together with a network architecture designed to support secure, all-informed calls between groups of users, made it the perfect choice to meet LOCOG's PMR requirements.

The network was built with the resilience and capacity to meet demanding Service Level Agreements for availability and Grade of Service (the design target was that less than 1% of calls should queue, for less than 1 second).

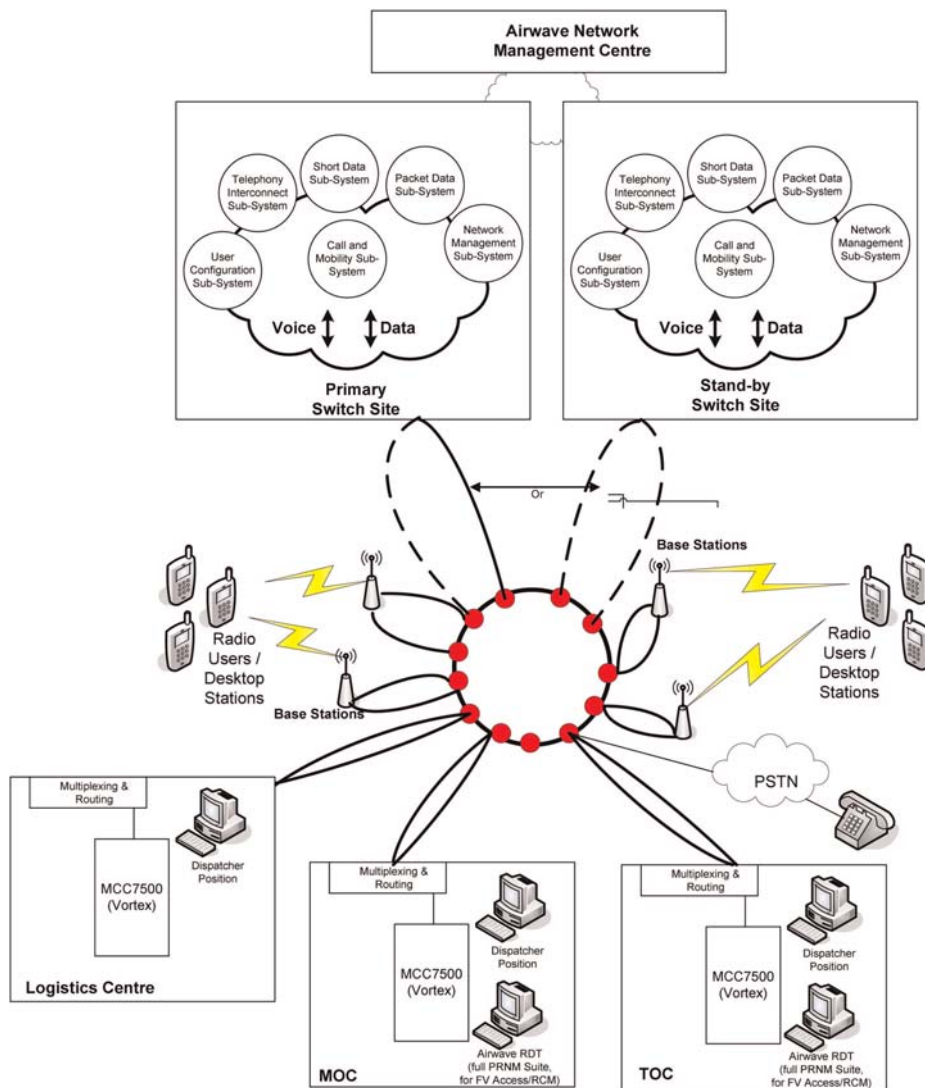
Resilient transmission links were used, together with a high level of redundancy in key network components. Enhanced operational support was deployed during Games time, ensuring that a rapid response was possible in the event of a fault. A range of capacity management techniques was also used to ensure the Grade of Service was delivered.

The primary means of communication was Group calls, with telephony and individual call capability for certain users.

The main components of the network are shown in Fig. 1, and performed the following functions:

- Two switch sites contained the main PMR switching equipment, subscriber management, call control and network management sub-systems. One site operated as a live primary and the other as a hot-stand-by with 100% equipment redundancy.
- Forty-five base stations provided radio coverage to all venues, the Olympic Route Network (ORN) in London and various other areas. All coverage areas passed extensive testing beforehand.
- Control room equipment provided access to dispatcher-based services at management and control locations operated by LOCOG.
- Transmission circuits provided resilient connectivity between the switch sites and base station sites/control rooms.
- The Airwave Network Management Centre accessed the network management sub-systems located at the switch sites.
- End user services were provided by hand-portable, vehicle-fitted and desktop mounted TETRA radios.

The network was designed to support up to 18,000 radio users, performing a range of operational, security, transport



**Figure 1** Airwave's Apollo network

and event management functions. Each user group had specific communication requirements, which were catered for by the definition of approximately 1500 Talkgroups.

To ensure the Grade of Service requirement was met, and to minimise the risk of network congestion, it was necessary to use a range of capacity management techniques. The capacity of each base station was designed to meet the radio traffic predicted for the users in each area, and careful network planning ensured that only the required traffic was generated at each site.

To limit the number of users who might access a particular base site, the TETRA Subscriber Class feature was used to define the sites which a radio was able to use. The Subscriber Class used by a radio was dependent upon the Talkgroup selected, providing flexibility to use a common radio configuration for all users at all venues.

Each Talkgroup was configured to be valid on only a subset of available base sites, preventing unnecessary duplication

of traffic. Together with the Subscriber Class feature, this ensured that traffic generated at each base station was kept within predicted limits.

Up to 2500 users could be accommodated under the footprint of base stations covering the Olympic Park area, and common secondary control channels were deployed on these sites to ensure enough capacity for call control and mobility management signalling.

In terms of actual performance, the network exceeded all key requirements, with over 7 million calls being carried by the system over the period of 27<sup>th</sup> July to 9<sup>th</sup> September (from the day of the Olympics opening ceremony to the day of the Paralympics closing ceremony).

Most of the network was installed and fully operational fifteen months in advance of the Olympics opening ceremony, providing ample opportunity to fully test the system and the operational processes depending on it. However, some parts of the network could only be



**Figure 2** TETRA hand-portable radio

delivered within a specific time window, such as the temporary installations required for supporting the cycling road races and the venue technology centres. With such a limited time to install and test these installations, this provided the biggest challenge in the whole programme. However, a good degree

of co-operation between Airwave and LOCOG technical staff ensured all problems were overcome.

With the heavy demand on radio spectrum from network operators, broadcasters and others, it was essential that a robust spectrum plan was drawn up in advance of the Games in collaboration with Ofcom to mitigate possible effects of interference. Spectrum in the 385–400 MHz range was temporarily allocated to Airwave, and this was used to provide the full range of LOCOG services. The small number of interference issues encountered during the Games had only a relatively minor impact on services, and were quickly investigated and resolved by Airwave and Ofcom engineers working collaboratively to identify the sources of interference.

An example of the hand-portable radio used is shown in Fig. 2.

As many of the radio users were volunteers, the majority probably with limited experience and knowledge of PMR, the user interface on each radio was designed to be as simple as possible. This limited users to basic functions, with restricted access to any of the more advanced features of the radios. Each user was given basic training in the use of the radios, but in order to assist in the resolution of any operational issues with the radios during Games time, Airwave ‘Ambassadors’ were present at each venue to offer practical help and advice to users.

# Paper 3 – Cyber Security and Resilience Overview

David Finch<sup>1</sup> Vijay Samtani<sup>2</sup>

<sup>1</sup>Senior Manager, Architecture and Security, LOCOG

<sup>2</sup>IT Security Manager, LOCOG

<http://uk.linkedin.com/pub/david-finch/2/a21/361/>

The Olympic Games is undoubtedly the most high-profile event that takes place on the world stage: audiences are measured in billions, success is a matter of national pride and the organising committee is in the media spotlight throughout the entire lifecycle. The successful staging of these games was more reliant on reliable and secure technology than ever before and the profile of London as the host city exacerbated the risks to the security of the Games. Through the years of preparation, sophisticated

attacks such as stuxnet emerged, numerous high-profile data breaches occurred against major corporations and hacktivists regularly caused disruption to websites around the world – including UK Government sites in early 2012. The threat, therefore, of cyber attack against the London Games, and the potential consequences of a successful attack, were both exceptionally high (Fig. 1).

In light of this, LOCOG's cyber security strategy focused on five key areas to reduce the risk to the delivery of the Games. Those areas were: governance of security, technology architecture, technical security operations, situational awareness and assurance. Governance, architecture and assurance activities were critical in the planning of and approach to the Games; during the Games, technical security operations and situational awareness came to the fore.

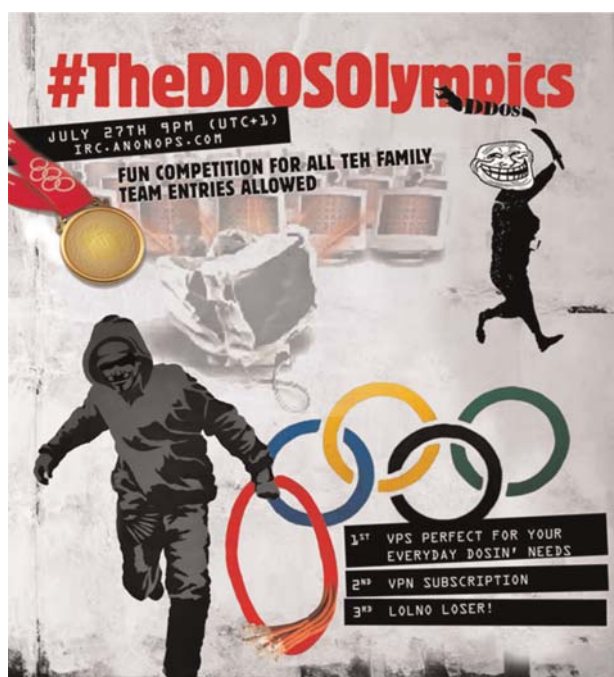


Figure 1 Threat posted on social media before the Games

## 1 Governance and assurance

The LOCOG Information Technology (IT) Security team held overall responsibility for cyber security across LOCOG, sponsors and suppliers. The team provided oversight of all IT systems implemented for LOCOG, establishing and following a standard risk review process. For each system, the profiling included an assessment of the sensitivity of data and the presence of personally identifiable information, captured information relating to security policies and processes and assessed security controls. Based on the findings, requirements were set as to minimum standards necessary for release.

Security testing was an essential element of the governance processes and a strict regime of security penetration testing

was adhered to. LOCOG commissioned independent suppliers to carry out testing in accordance with the CHECK methodology, meaning that they have met quality standards set by CESG (further details available on the CESG website, <http://www.cesg.gov.uk>). The LOCOG team reviewed and assessed the results of each test, establishing a remediation plan that accounted for any additional context that might make a vulnerability more, or less, of a priority than determined in isolation by the test specialists. As a general principle, no system was to go live with any outstanding critical or high vulnerability; however this was further extended to medium and low if considered necessary because of the threat level. Of course, because security testing was always one of the final activities carried out prior to a launch, this carried the risk of slippage because of last minute surprises.

This regime of testing is considered a critical success factor in IT security for the Games: over a period of approximately 18 months, nearly 50 tests were carried out and a number of critical vulnerabilities identified and remediated. This provided the Security Operations team with a measure of confidence when dealing with cyber security incidents and helped them to focus efforts more appropriately.

Throughout the project, LOCOG maintained a close working relationship with the Centre for Protection of National Infrastructure (CPNI) and Government Olympic Executive (GOE), interfacing through these two bodies to other agencies involved in cyber security. This was beneficial to both parties, providing the UK Government with assurance as to the systems being implemented for the Olympic Games as well as providing additional assistance to LOCOG in terms of independent technical review. This relationship was also important in establishing the Olympic Cyber Coordination Team (OCCT), put in place to facilitate communication and help coordinate the response to cyber threats across the many organisations involved operationally in delivering the Games. To ensure awareness of the Olympics environment and critical systems, a series of briefings were given by LOCOG to staff from the OCCT and supporting organisations.

## 2 Technology architecture

Understanding that LOCOG were operating with a low-risk appetite in a high-threat environment, security controls taking into account both corporate and UK Government best practices were incorporated into technical designs. The following summarises the four most important domains and the primary security considerations of each:

- The BT network was primarily focused on availability and, whilst still important, the integrity and confidentiality of data carried across that network was ultimately the priority of the systems using it. BT designed a sophisticated converged network delivering services to internal LOCOG users,

Olympic Family (including press, broadcasters and athletes) as well as to the general public and it was essential to protect this network and limit the reach of any malicious traffic originating either externally or internally. Again, it was a certainty that this would be a real issue: any system with an Internet connection will see malicious traffic and the Games were no different, but monitoring systems frequently identified malware activity on third-party machines using the network, which was invariably unknown to the owner.

- The Atos Games IT systems made use of the BT network for transport to/from venues and the data centres. These systems provided critical Games-Time services including the distribution of results and hosting of operational systems such as Accreditation, therefore no compromise was possible in assuring the confidentiality, integrity or availability of data. Using a well-proven approach from previous Games, this environment was heavily locked down with tightly controlled external interfaces and a complete absence of Internet access and email for all users.

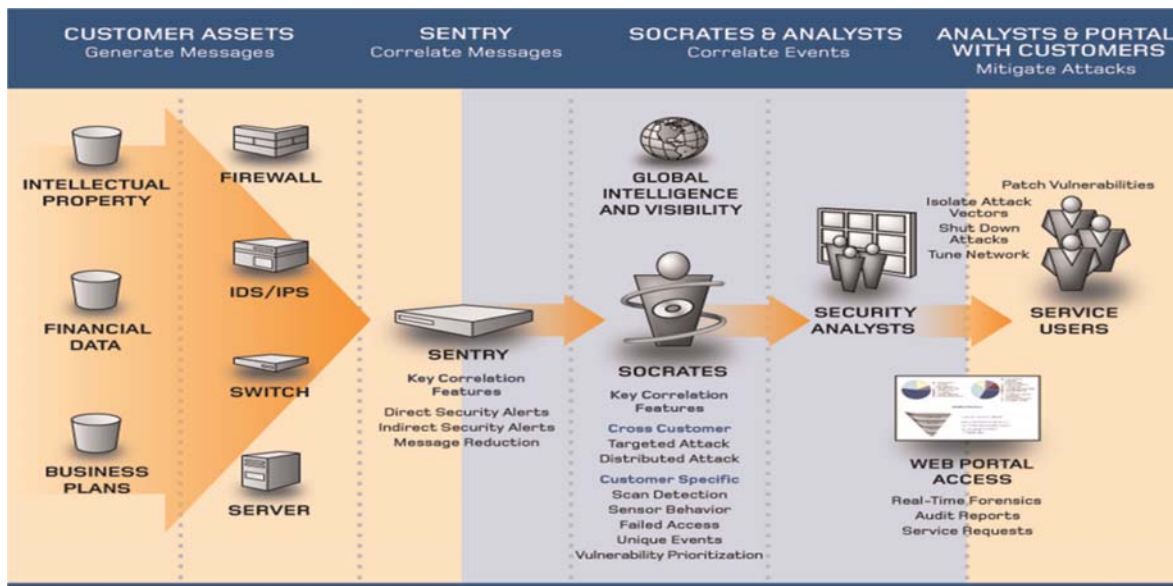
- A new Office Admin corporate infrastructure was designed by LOCOG during 2009 and rolled out in early 2010, introducing a high degree of standardisation and incorporating many security controls new to the organisation. Key within this was to put bounds on the capabilities of users; however as the primary day-to-day working environment it was essential to achieve the right balance between security and usability.

- The London 2012 Games-Time Website (<http://www.london2012.com>) was the most highly visible system deployed, receiving massive demand during the Games. However, this was only one of many websites implemented by or for LOCOG for use in the lead up to, or during, the Games. These websites were of course the most obvious target for any attack – particularly a denial of service – and they were required to meet a defined set of application security standards and fit within an overall security ‘umbrella’ to benefit from controls available from the content delivery network.

## 3 Technical security operations

The LOCOG Security Operations team were based in the Technology Operations Centre (TOC) before and during the Olympic and Paralympic Games, monitoring and managing incidents arising from their suite of security tools, logged by the service desk or escalated by a sponsor, supplier or the OCCT.

The BT Network, Office Admin corporate infrastructure and the Games-Time Website shared a common protective monitoring surveillance solution, BT Counterpane; a separate dedicated system was deployed by Atos for the Games IT Systems in line with previous Olympic Games



**Figure 2** Security Event Monitoring

and this is detailed in a later section. The systems and infrastructure within these three domains continually emitted event logs and diagnostic messages which were received, correlated and assessed by LOCOG’s security analysis systems. The overwhelming majority of such messages required no action to be taken. A very small fraction (typically under one-tenth of one percent) required further analysis, and from this activity, the TOC received alerts to investigate potential breaches of security.

Tables 1 and 2 summarise the overall statistics for the period of the Olympic Games and Paralympic Games respectively. In each of these tables, the first column provides a reference for an equivalent period of time to each of the Games.

The large increase in the number of security-relevant events for the period of the Olympic Games is largely attributable to planned increases in sensitivity of the

**Table 1**

	One month to go 27 June–13 July	Olympic Games 27 July–12 August
System messages collected	1060 million	2352 million
Security-relevant events	14 million	139 million
Incidents alerted to the TOC	122	97

**Table 2**

	Two weeks to go 15–26 August	Paralympic Games 29 August–9 September
System messages collected	807 million	806 million
Security-relevant events	26.8 million	26.4 million
Incidents alerted to the TOC	55	68

protective monitoring systems. The number of alerts issued to the TOC did not increase however, which indicates that the baseline sensitivity levels were not causing relevant events to be ignored. Rather, the change in sensitivity provided richer contextual information to support the analysis of those alerts.

## 4 Situational awareness

In the approach to the Games, the LOCOG Security Operations team had built an extended network of cyber security contacts across sponsors, delivery partners and internally to other functional area command centres responsible for physical security and brand protection. In the case of technology delivery partners, information sharing and collaboration relationships were particularly strong, with partner security specialists occupying positions in the TOC on a 24 × 7 basis during the Games. The TOC had previously engaged with other partners and

sponsors and set up protocols for information sharing. These protocols were used during the Games both for the TOC to disseminate information to the sponsor and partner community, and also for the cyber security teams within the sponsors and partners to communicate directly with their equivalents in the TOC. LOCOG had also built strong relationships with members of the UK Government's cyber security community, all accessible through the processes established with the OCCT. The TOC and the OCCT had in early 2012 implemented both technology and processes for secure communication and successfully tested those processes in Technical Rehearsal 2 in May 2012.

In the approach to and during the Games, the TOC and OCCT were in regular contact, and information flowed in both directions. The OCCT provided general intelligence and risk analysis on an ongoing basis, as well as specific advice and guidance on request.



# Paper 3A – Corporate Infrastructure

*David Finch*

Senior Manager, Architecture & Security, LOCOG  
<http://uk.linkedin.com/pub/david-finch/2/a21/361/>

As stated previously, the corporate infrastructure underwent a substantial refresh in early 2010 to put in place a platform capable of supporting the organisation through the Games and up until dissolution. This move to the strategic platform was a substantial transformation, introducing much stricter security controls, significantly increased resilience and a migration to the sponsored Acer desktop, laptop and server hardware. Key aspects of this new environment included:

## 1 Desktop environment

Microsoft Windows 7 was selected for client devices in conjunction with Microsoft Office 2007, ensuring that a supported operating system and desktop productivity tools (and therefore security patching) were available through the rest of the project. A hardened Windows 7 build was deployed with Group Policy being used to define domain-wide security settings and new features were used to improve the security posture, including AppLocker to restrict the software that could execute and BitLocker for hard disk encryption, the latter being used in conjunction with the Trusted-Platform Module (TPM) that had been specified in all the Acer systems to protect cryptographic keys. End-point security was of course also deployed to all Windows 7 machines.

Prior to the upgrade, users enjoyed much greater 'freedom' with many having local admin rights; there was also a plethora of applications (including browsers) often fulfilling the same purpose and no restrictions on USB sticks and removable media. The transformation project addressed these issues, removing local admin from all users and defining a core set of applications; policies were also implemented requiring USB pen drives to be encrypted before writing and to limit CD writing permissions.

Alongside this, strict change control procedures were established to ensure that the integrity of the new environment would not be compromised.

## 2 Server environment

Microsoft Windows 2008R2 with Hyper-V was used to create a new virtual server environment for LOCOG, bringing additional levels of resilience by enabling automated failover. This also facilitated the introduction of an off-site server farm with SAN replication for disaster recovery. Group Policy was used for baseline security settings, with customisation depending upon the particular application or service running. Additional software was deployed on the servers for end-point security, to monitor for unauthorised changes and to forward audit logs for analysis and correlation.

## 3 Network infrastructure

BT and LOCOG worked closely to ensure alignment of the new strategic network design and the new Office Admin environment. More details on the network are provided later in this section, however a number of important aspects are highlighted in Table 1.

Later in the project, Identity-Based Network Services (IBNS) were also introduced to ensure that only permitted client devices could access the Office Admin environment, although attempts to implement full 802.1X functionality timed out because it was not possible to guarantee the required levels of reliability in all circumstances. This was disappointing given the very homogeneous nature of the infrastructure; however it reflects the pragmatic risk-based decision making that is necessary to deliver the Games: the solution needed to be in place for extensive proving

**Table 1**

Data Centre Firewalls	Deployed in addition to the multi-layer Internet firewalls, the Office Admin server farm was also protected by a dedicated firewall infrastructure.
Proxy	Proxy infrastructure was deployed with Anti-Virus scanning of incoming file downloads. Policies were configured for the forward proxy functionality to limit the websites accessible to users; reverse proxy was also used for external access to a number of internal services.
Intruder Detection Systems	Cisco Intruder Detection Systems (IDS) were deployed at strategic points in the network with logging for analysis and correlation.

during test events in order to mitigate any risk to the Games.

## 4 Security patching

Ensuring that software and operating systems were kept up-to-date with the latest security patches was considered of paramount importance. LOCOG used regular scheduled patching windows to achieve this, plus emergency patching when necessary. This was a difficult process sometimes compromised by the frequent change freezes necessary for test events, technical rehearsals and other key periods of activity and again, risk-based decisions were necessary to determine if a particular security patch needed to override the freeze. In the last few months leading up to the Games, a concerted effort was made to ensure that all patching was completed in order to minimise the security risk and the likelihood of patching during the Olympics and Paralympics.

## 5 Cultural change

Of course, the refresh of the Office Admin environment met with resistance at the outset. Although there is no

doubt that the vast majority of users understood the need for greater security as the Games approached, there was frustration from a busy workforce having to learn new ways of working, including how to use Windows 7 and Office 2007 with the ribbon user interface. The transformation project included user communication and training to address this challenge and minimise user frustration; in addition, 'floor-walking' support was provided to users on the day of migration. Ultimately however, the new environment was accepted and within a short period, the service desk experienced a downward trend in service incidents despite rapid growth in user numbers, notably reversing the trend from before the transformation.

From the outset and right through to the Games, security messaging was repeated again and again. This commenced with the initial staff induction training but continued with frequent online messaging, poster campaigns, e-learning and a security awareness week to make sure that an ever-increasing workforce would continue to be mindful of the security threat.



## Paper 3B – Games-Time Website

David Finch<sup>1</sup> Vijay Samtani<sup>2</sup>

<sup>1</sup>Senior Manager, Architecture and Security, LOCOG

<sup>2</sup>IT Security Manager, LOCOG

<http://uk.linkedin.com/pub/david-finch/2/a21/361/>

It was always anticipated that demand on the London 2012 website would be huge, with a worldwide audience expecting it to be the authoritative source of information on athletes, schedules, results and more during the Games and in the lead up. As such, it could clearly be the number one target for a denial of service attack which, if successful, would disappoint millions of users and represent a significant reputational impact to the Games. Whilst confidentiality was clearly not an issue with a site for which the priority was to distribute information as quickly as possible, integrity was vital to ensure results and so on were accurate and that there was no embarrassing defacement of any content.

With this level of threat, the design of the website had to take advantage of all the security controls available. In terms of the data centre infrastructure, the controls in place were fundamentally an exercise in best practice: an active-active data centre configuration employing high-availability, with each data centre capable of handling full load; tightly configured firewalls; intruder prevention; security event monitoring; anti-virus; strict patching regimes; restricted access controls and more. There was nothing particularly unusual within this environment: it just required robust, secure design, implementation and operation in very challenging timeframes.

In order to meet the capacity demands expected at Games-Time, the site made extensive use of a content delivery network (CDN) whereby the majority of content was static. This content was made available on the data centre servers (referred to as the origin) and propagated across the many thousands of CDN servers distributed around the world as users made requests. Once website content was cached in this way, further requests were met by the CDN servers

without recourse to the origin until that content had expired in accordance with the Time-To-Live (TTL) settings: the latter were varied based on the nature of the information and how quickly it could change, with results information having the shortest TTLs because of the frequency of live updates during competition. Overall, this approach enabled in excess of 95% of all content to be delivered directly by the CDN.

Given this mode of operation whereby all user requests were handled by the CDN, extensive use was made of security features available within the CDN to protect the origin data centre infrastructure, which was the source of all content. As a starting point, the data centre firewalls were configured such that they would block any traffic that was not coming from CDN servers, thus preventing any users from directly interacting with the origin servers. Although this provided an excellent safeguard for the infrastructure sitting behind those firewalls, it could not actually stop any traffic from consuming bandwidth on the BT Internet connections to the data centres or prevent resources from being consumed on the firewalls themselves; therefore additional Distributed Denial of Service (DDoS) protection was specified to enable malicious traffic to be 'black-holed' at the internet level if necessary.

With the website origin effectively protected from traffic bypassing the CDN, further security controls were used to assure the integrity of requests coming 'through' the CDN. These controls prevented common attacks such as SQL injection, but also a much more sophisticated and comprehensive firewall configuration was established across the CDN servers receiving the user requests. These rules were used to block malicious traffic as close to where it was originating as possible, thus preventing any downstream

impact and most importantly, preventing any origin infrastructure from wasting valuable resources trying to block or service it.

There were a number of specific use cases for the website which required a greater amount of processing by the origin rather than a simple return of static content, the most notable example being the search function. In this case, the CDN could not simply provide static content to the user because it required the origin servers to determine the response based on what the user was searching for. This represented a denial of service vulnerability, whereby large numbers of perfectly valid requests submitted in very significant volumes, for example, from a malicious script, could overwhelm the origin. To counter this, the CDN firewall rules were configured to rate-limit such functions: below the threshold considered as normal activity a user could submit search requests, but if this threshold was exceeded the requests would be blocked.

Finally, another key element of the security of web-facing systems was to ensure the integrity and availability of DNS: to cause disruption at this level would fundamentally impact ability to communicate with the websites supporting the London Games. A distributed DNS service was used

for this purpose, again with the origin or source DNS servers being locked down so that they could only be accessed from the CDN.

## 1 The Games Begin

The media profile of the websites, and the public interest in them, surged dramatically as the Olympic Games commenced, with a 68-fold increase in page views over the period one month before the Olympic Games. There was a much more modest increase in the number of security events detected, although again the number of incidents triggering an alert did not increase. In fact, this number actually dropped, as a result of the TOC Security Operations team fine-tuning the alerting system immediately before and in the early days of the Olympic Games. Note that the figures in the tables below represent a subset of those in Tables 1 and 2 from Paper 3 – Cyber Security and Resilience Overview.

For the Paralympic Games, there is a similar rise in website traffic during competition, but the number of security events and incidents alerted to the TOC remain stable. The fine tuning carried out in the early days of the Olympic Games benefitted the Paralympic Games. Statistics are summarised in Tables 1 and 2.



Figure 1 Threat posted on social media before the Games

Table 1

	One month to go 27 <sup>th</sup> June to 13 <sup>th</sup> July	Olympic Games 27 <sup>th</sup> July to 12 <sup>th</sup> August
Website page views	70.3 million	4783 million
System messages collected	151 million	372 million
Security-related events	13.3 million	125 million
Incidents alerted to the TOC	54	31

**Table 2**

	Two weeks to go 15 <sup>th</sup> –26 <sup>th</sup> August	Paralympic Games 29 <sup>th</sup> August to 9 <sup>th</sup> September
Website page views	41.5 million	132.5 million
System messages collected	130 million	143 million
Security-related events	23.4 million	23.3 million
Incidents alerted to the TOC	5	3

The following two incidents illustrate the nature of cyber security attacks against the London 2012 website (www.london2012.com) in the last days and hours leading up to the Olympic Games. These are only two examples and with the effectiveness of the security controls confirmed, the Security Operations team were able to maintain a watching brief across other such attacks without having to intervene or carry out a detailed investigation and analysis.

### **1.1 Incident 1: 26<sup>th</sup> July 2012**

On 26<sup>th</sup> July, at 1700 h, an attack was launched against the www.london2012.com website. It lasted approximately 10 minutes and the vast majority of traffic was blocked by firewall controls configured at the perimeter of the content delivery network. No performance or other impact to the website occurred and analysis of the traffic by the TOC

Security team indicated that the originators were likely probing for technical vulnerabilities to publicise.

### **1.2 Incident 2: 27<sup>th</sup> July 2012 – four hours before the opening ceremony**

On 27<sup>th</sup> July, at 1637 h, an attack was launched against the www.london2012.com website. Analysis by the TOC Security team showed that the attack lasted approximately 40 minutes, during which over 10 million requests were made for a single resource. Again, all this traffic was blocked by firewall controls configured at the perimeter of the content delivery network. Originating from approximately 90 different IP addresses in various geographies, the start and end times of the attack were well defined, indicating some form of automated synchronisation. Other than to trigger an operational monitoring alert, there was no performance or other impact.



# Paper 3C – BT Communications – Internet and Network Security

*Stuart McMillan*

*Technical Assurance Manager, BT London 2012 Programme, BT  
E-mail: stuart.w.mcmillan@bt.com*

## 1 London 2012 Communications Internet and Network Security

### 1.1 Network Security

The approach to security for the services delivered to London Organising Committee of the Olympic and Paralympic Games (LOCOG) and its customers adhered to standard thinking around Confidentiality, Integrity and Availability (CIA) with strong emphasis on Availability. This CIA skew was specifically adopted to allow the rapid uptake of services (in the main internet services) by a large number of users (c22k press users) with minimum operational security involvement and a relatively small team of administrators.

This section will detail the specific mechanisms in the environment that allowed the network and security operations of the Olympic Games to proceed with no major information security incidents. It has been broken into logical groupings relating to specific product domains that had different security requirements.

## 2 Base Internet Security

Base Internet security is the gross security envelope applied to all internet services, although, as will be discussed later, there were further refinements in the specific product domains as the customer groupings were split between internal corporate ('Office Admin') users and external customers who purchased Internet access via the LOCOG 'rate card'.

Internet services were provided from the standard BT product portfolio, delivered on multiple 10 Gbps connections into the UK BT network that peers with other ISPs in both the UK and internationally. These

connections were multiply delivered to two Points of Presence (PoPs) in the London area (see Fig. 1). To provide a measure of protection against Distributed Denial of Service (DDoS) attacks, the links were protected by Arbor Networks Peakflow product. This product has an option to deliver automated threat mitigation although this was not used in this instance as there were concerns that it would be impossible to simulate actual games behaviour in advance and hence the many customers using the internet service might unwittingly trip or trigger the system. Instead, BT security operations received alerts if the threat management system became aware of suspicious activity and discussed with LOCOG security operations whether to take any mitigating action.

Each of the London PoPs was constructed in a way that delivered High Availability (HA) locally, with full geographical resilience for the services being delivered. This resiliency was fully tested as part of commissioning of the services to LOCOG. In addition to the HA at the PoPs (to prevent against hardware failure) multiple firewall vendors were chosen operating in series to prevent single vendor vulnerabilities from compromising the integrity or availability of the network. This technique ensures that any given attacker has to be able to exploit vulnerabilities in two distinct systems simultaneously in order to gain access.

In addition to these standard internet techniques, BT also received vulnerability reports from the UK Computer Emergency Response Team (CERT) to ensure that known threats were understood in respect of the infrastructure delivered to LOCOG.

Finally, in relation to basic internet security, BT also worked with a social media monitoring partner to analyse

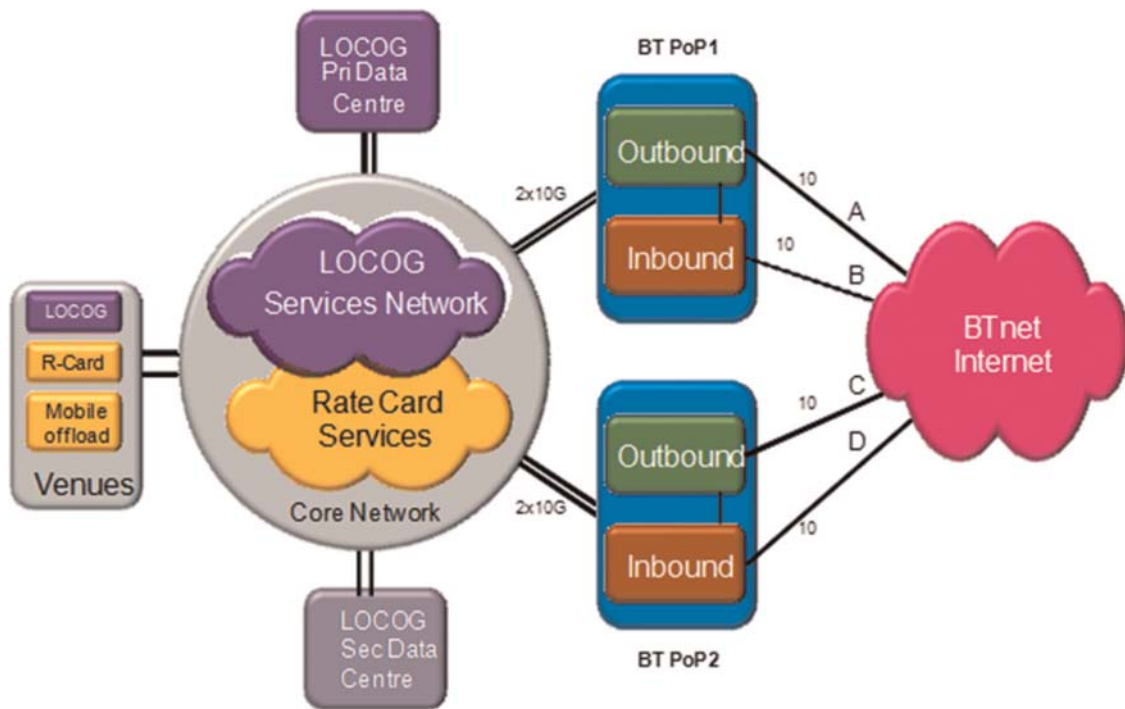


Figure 1

common terms on public fora (e.g. twitter), heuristically harvesting pertinent information and subjecting this to detailed human analysis.

### 3 Corporate Client Security

Although the provided network is wholly consolidated, running all services on a converged basis, the corporate or 'Office Admin' network had to run as an effectively separate environment and security domain to protect the services that LOCOG needed to run as a business. This included the wired connections for desktop PCs and IP phones, and a server, build and test network, all kept in isolation from 'rate card' services (such as wired and wireless internet access and cable TV (CATV) services). There was no requirement for specifically secured wireless access to the Office Admin network.

Following recommended best security practices, the main separation was delivered using standard Cisco VLAN security, but to prevent inadvertent or malicious connection of customer equipment to this private network, Identity Based Network Services (IBNS) were used to authenticate all LOCOG network service devices (phones, PCs and laptops) in all consumer areas. Ports that were tagged at the switch as admin that subsequently had an unauthenticated device plugged into them would be transferred to the rate card network for the user to authenticate to obtain access to the internet.

Standard network protection techniques were used to provide additional security at port level, including IP ARP

inspection (to determine MAC address validity), IP source guard (preventing/limiting IP spoofing vulnerability), port security, broadcast/unicast storm control and ACLs to prevent unauthorised inter-VLAN communication. While LOCOG provided the security features on the desktop and laptop PCs, internet access provided by BT was mediated via a proxy infrastructure at the PoPs with standard business category limitations on gambling, pornography and so on, illustrated in Fig. 2.

Additional internet browsing security was provided in the shape of iCAP connected Anti-Virus devices to prevent malicious products from being downloaded into the infrastructure.

Remote access to the corporate network was provided via a multi-factor authentication system installed at the PoPs, providing both 'fat-client' IPSEC access for LOCOG build PCs and laptops, and 'light' browser based access for other devices, with limited access to corporate resources.

For access to systems and resources provided by other organisations (e.g. call centre services, hosted externally with separate providers), dedicated network VPNs were set-up to these organisations or where the systems were hosted on the internet, https access was enforced.

While LOCOG handled email communications security, to facilitate simple and secure interworking, BT and other partners used Transport Level Security (TLS) for email

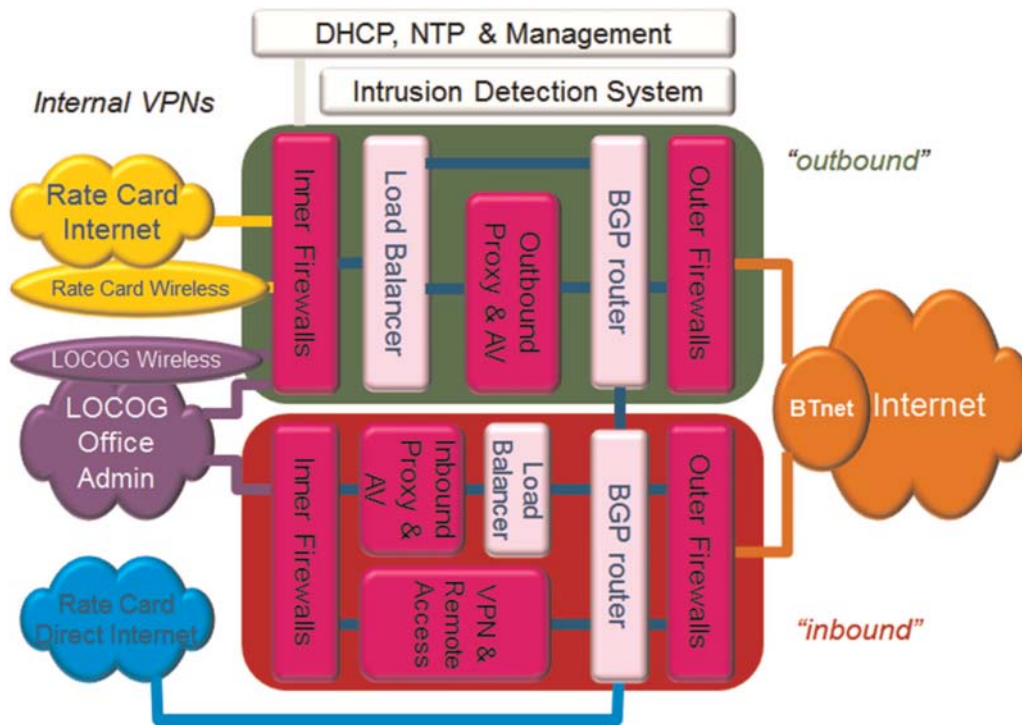


Figure 2

between organisations, allowing documents to be sent securely without first encrypting them.

Finally, BT Counterpane provided a log consolidation and heuristic analysis service for the LOCOG internal server farm, allowing the collection of server, host intrusion prevention and network logs and providing LOCOG security administrators the ability to simply identify areas for concern within the Office Admin environment. This security was tested and validated by external penetration testing of the Admin environment. During the Games, this BT Counterpane Threat Monitoring Solution analysed a total of 2.17 billion events which were correlated to 76 tickets raised to our customer, of which 15 were regarded as suspicious.

#### 4 Internet Customer (Rate Card) Security

Rate Card internet access was delivered as two product sets to meet the demands of the LOCOG customer base.

The main population of press and media descending on the Olympic Games required the creation of an ISP-like pay on use service, with a simple and easily understood usage paradigm. Given the uncontrolled nature of their IT infrastructure, they represented a particular threat, for example, there were no guarantees that their PCs would have Anti-Virus software present on them, and, therefore security controls around them needed to be watertight. In particular, access control lists on their switch ports

limited their access, and specific penetration testing was undertaken. VLANs were setup for their services at each venue and on ports dedicated for this use, and additionally on Admin ports that failed the IBNS test. BT and LOCOG used a simple landing page which was delivered from dedicated proxies and backed off to a simple LDAP database of paying customers. In addition to this function, the proxies used provided caching and stream splitting and contained a very lightweight policy set to prevent users from accessing known illegal (in the UK) websites.

The standard wireless service operated using the same authentication and control mechanisms.

Some specific large customers (such as broadcasters) had higher expectations and generally arrived with a full suite of IT equipment, only requiring power and internet connectivity to enable their services. These customers took specific Direct Internet Access (DIA) connections that worked like standard full ISP connections but delivered on the consolidated infrastructure. These connections were unsecured to the internet, requiring the consumers who took them to provide their own internet security, however there was still a need for further monitoring of connections to ensure that this was effective.

All these connections were delivered at pre-determined speeds, either limited by the transport connection (10M or 100M) or by simple rate limiting on the core switch infrastructure at the PoPs to prevent saturation of PoP to venue connections.

## 5 Security operations

BT's security operations team was run from the LOCOG Technology Operations Centre during the Games-time period, with specific personnel tasked with monitoring and analysing information from the main LOCOG environment and the website.

Operational accounts on network switches and firewalls were secured centrally against a TACACS service using multi-factor authentication, with multiple levels of Role-Based Authentication and control (RBAC). The RBAC levels (e.g. for local site engineers), allowed basic show commands, but limited substantial changes. This was a specific part of BT's defence in depth strategy which placed strict controls about change during competition times and required the central administration team to authorise and administer anything that might have an impact on operational service on a large scale.

Operational tooling managed configuration management, with full backups being taken nightly from all devices (switches, firewalls, servers etc.), with consolidated views from all switches on the system monitoring team consoles and consolidated security monitoring on the security operations team consoles.

In the run up to Games-time operations, weekly 'bug scrub' meetings took place with the main switching and security systems suppliers, in order that known weaknesses were understood and mitigations, where needed, were put in-place.

During Games-time service operations, only zero-day vulnerabilities were considered for patching or mitigation. As discussed at the head of this section, the emphasis was focused on keeping the service available, with reasonable levels of confidentiality and integrity.



# Paper 3D – Atos Games Information Technology Systems Security

Shailesh Chauhan<sup>1</sup> Clive Grethe<sup>2</sup>

<sup>1</sup>Atos Technical and IT Security Manager

<sup>2</sup>Atos London 2012 Account Director

E-mail: [Olympic\\_Games@atos.net](mailto:Olympic_Games@atos.net); [clive.grethe@atos.net](mailto:clive.grethe@atos.net)

As the Worldwide Information Technology (IT) Partner for the Olympic Games and Paralympic Games, Atos were responsible for the programme management, integration, development and operation of a range of applications essential to delivering the London 2012 Games. The Info Diffusion Systems (IDS) fulfilled the vital task of receiving, processing and disseminating results and other information to key stakeholder groups including the press, broadcasters, athletes, officials and international sporting federations; they also provided the real-time data feeds to third-parties responsible for delivering systems such as the official London 2012 website and mobile results application and broadcaster results systems. The Core Games Systems (CGS) provided a tightly integrated suite of applications to underpin key business processes necessary for running the Games, including managing:

- Accreditation of all individuals attending in an official capacity, plus a new access control service to verify physical access permissions.
- Registration, selection and scheduling of staff and volunteers.
- The submission process that enabled athletes to participate in their given sports.
- The capture and processing of information relating to provision of medical services.

Clearly it was of paramount importance to maintain the safe and secure operation of these systems leading up to and during the Games. Failure or compromise of the Info

Diffusion Systems would have been damaging to the very spirit of the Games with the potential for severe reputational impact; a compromise of the Core Games Systems might have disrupted the organisation, involved data leakage or even impinged upon aspects of physical security at venues with potentially serious consequences.

Atos have held the role of Worldwide IT Partner since 2001, achieving successful delivery of five Olympic and five Paralympic Summer and Winter Games before London 2012, but the core systems used today are an evolution of those first seen in Barcelona in 1992. During these 20 years, Atos have successively refined and improved their approach in response to the increasingly important role that IT plays in the successful delivery of the Games. The rate of change continues at an ever increasing pace and from a cyber security perspective the landscape has moved on significantly: there has been a drive to make information more freely available to users via the internet and on their own device, with a corresponding increase in the likelihood of cyber attack leading to a denial of service or compromise of data. In common with any modern enterprise, the London 2012 Games have had to face these challenges but, perhaps more unusually, also whilst working to an immovable deadline and under a media spotlight that would be very attractive for a would-be cyber attacker seeking to publicise their cause.

Meeting the business need of enabling users to more readily access information where and when they need it, Atos introduced a range of new services for the London 2012 Games; out of necessity this extended the attack surface of the Games IT Systems [A collective term

**Table 1**

myInfo <sup>+</sup>	A web-facing version of the Info <sup>+</sup> system used primarily for the 27,000 accredited journalists, but also serving the needs of other groups such as International Sporting Federations. myInfo <sup>+</sup> allowed users to access results and other information from their own device in venues and externally from the internet. This information store enabled rapid creation of articles with facts and figures to fill media sites with hundreds of thousands of stories to meet the demand of the world's readers
Olympic Data Feed over internet	The real-time provision of the Olympic Data Feed to press agencies and International Sporting Federations across the internet
Identity Management	To manage and support user account set up for the Atos Games IT Systems and LOCOG rate card internet access service, including those using their own devices (Bring Your Own Device – BYOD)
Remote Access Gateway	Enabled access to CGS and IDS applications from other LOCOG systems and provided the gateway to myInfo <sup>+</sup>

encompassing the IT Systems designed, implemented and operated by Atos to support the CGS and IDS] by providing support for untrusted third-party devices. These new services are listed in Table 1.

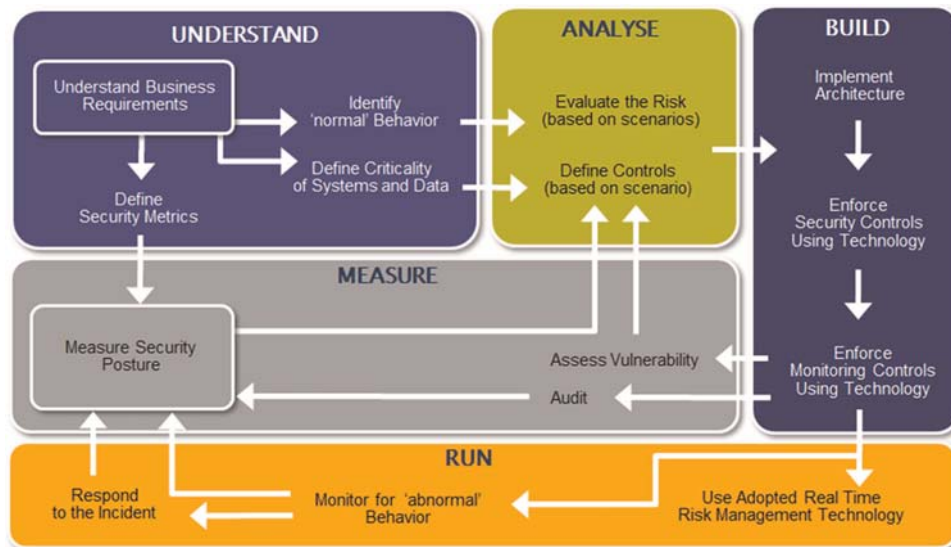
Further details of the myInfo<sup>+</sup> and Identity Management services are provided in the section ‘Supporting Third-Party Equipment’.

## 1 Proven approach – Atos IT Security methodology

The Atos IT Security team followed a proven approach from previous Games throughout the project lifecycle, as illustrated in Fig. 1. The remainder of this section outlines two foundational elements within this methodology, the business impact analysis and security risk assessments,

including an example of how it served to improve the security posture of London 2012.

At the commencement of the programme, the team initiated a business impact analysis (BIA) to establish an understanding and agreement of the LOCOG business requirements. Consulting with the LOCOG business owners, the BIA involved a review of each of the Atos services to determine key attributes such as identification of the primary users, critical operational periods, acceptable (manageable) levels of downtime and the consequences of a failure. A score was agreed for the impact along with determination of the components, resources and facilities critical to the service plus important criteria relating to disaster recovery, such as timescales and recovery priority. Reflecting a unique aspect of the Games, the definitions used to determine the business value of services (and hence the impact scoring) included consideration of how a failure



**Figure 1** Atos IT Security Methodology for London 2012

might impact upon sport competition and the degree to which it would be visible to the media. The output from the BIA was used to inform a number of streams within the Atos programme, including architecture, security and operations.

Stepping forward into the analysis phase of the IT Security methodology, the IT security risk assessments carried out were considerably more technical in nature than the BIA and reviewed the security posture of each service, taking into account the means by which an attacker might gain access to a system or data, compromise data integrity or cause a denial of service and whether that would result in a threat to confidentiality, integrity or availability. These risk assessments considered the efficacy of a baseline set of security controls and determined a risk rating based on impact and probability; those ratings were then reviewed and agreement was reached with LOCOG as to whether to accept the risk level or to improve the situation with additional security controls.

From past experience of Olympic and Paralympic Games, the Atos team were well aware of the challenge of balancing functionality versus security for the On-Venue Results (OVR) systems operating within the venues and critical to the capture and processing of results information. The Official Timekeeper, Omega, operate these systems and require flexibility and the ability to react immediately to any issues that might arise during an event and therefore security controls must be as unobtrusive as possible. Through use of the IT Security methodology and taking into account that the profile of the London 2012 Games demanded a lowering of the risk appetite, security was enhanced with use of 802.1x RADIUS authentication to restrict connectivity to the OVR networks and improvements were made to limit the reach of user accounts. It is envisaged that these changes will now be carried forward to future Games.

The initial business impact analysis and risk assessments created a set of baselines for IT security that remained subject to continuous review throughout the remainder of the programme.

## 2 Security architecture – zero breaches

Atos have always ensured that security is pervasive throughout the Games IT Systems and this is a key discipline where there is no room for compromise. An important aspect of the environment is that many systems deployed to venue are only required to support a single business function, and Atos maximise the advantage that this brings. For example, commentators only require use of the Commentator Information System (CIS) within IDS, therefore they are provided with a touchscreen PC that can

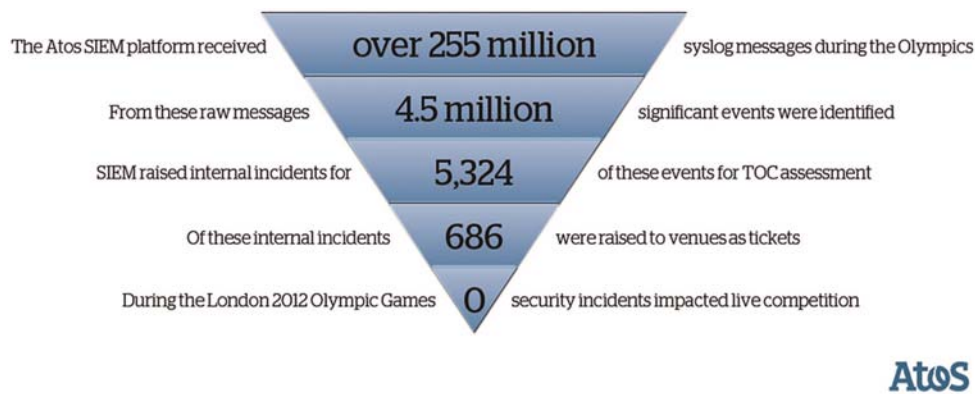
do nothing else but run this one application. For London 2012, this mode of operation completely removed the need for some of the most easily exploited attack vectors such as email and browser-based web access on Games IT Systems, and with the exception of the specific web-facing systems deployed to service external users, it meant that the external threat was significantly reduced. Despite this however, a defence-in-depth strategy saw an extensive array of security controls put in place to protect the core CGS and IDS applications, such as:

- Segregation within the network for the various IDS and CGS applications and the technical systems used for monitoring and supporting the environment.
- Hardened builds.
- Kiosk configurations to limit Personal Computers or laptops to a specific pre-determined application.
- End-point security, including network threat protection.
- Data integrity monitoring, to identify unauthorised changes to critical files.
- Blocking of USB memory sticks.
- Intruder Detection Systems (IDS).

To provide assurance that the security controls were fully effective and to highlight any vulnerabilities, a range of security penetration tests were carried out in close co-operation with LOCOG. These tests were against both the internal network and the external web-facing applications using several independent test organisations.

To support situational awareness across the full extent of this architecture, the Atos Games IT Security team deployed a Security Information and Event Management (SIEM) solution. This captured all manner of log information, resulting in a massive data set with individual log entries reflecting system health, user activity, traffic source information and so on. Real-time analysis engines processed this data in order to identify the threats hidden within it, alerting the IT Security team and enabling them to raise security incidents and carry out detailed investigation and remediation, effectively operating as a 24x7 Security Operations Centre (SOC) within the Technology Operations Centre (TOC).

The effective harnessing of the log data flowing from the network and systems continues to be a key success factor in the delivery of the Games and the statistics in Fig. 2 clearly demonstrate the need for such a highly automated approach.



**Figure 2** Games IT Systems, Security Information and Event Management Statistics

### 3 Policies, procedures and user education

Along with establishing the technical controls necessary to secure the Games IT Systems, the IT Security team also developed a range of security policies and procedures. Many of these were also technical in nature covering topics such as patch management, system builds, network and firewall policies, whereas others were more focused on the people aspects of the project and included policies for information security, change management, acceptable usage, service desk operation and so on. Again, taking the approach from previous Games but also reflecting typical best practice, users were provided with security awareness training from the very start of their role to promote correct handling of information and adherence to policy.

With many of the Core Games System applications going live significantly in advance of the Games, the Atos IT Security team were required to be operational well before the day of the Opening Ceremony. However, it was still essential to take advantage of the two Technical Rehearsal exercises in order to practice the processes and procedures necessary for managing security incidents during the Games. These two exercises are covered more fully in the

separate papers on Technology Operations, but they required the IT Security team to deal with planned scenarios ranging from SQL Injection attacks through to attempts to connect unauthorised equipment to the Games IT network.

### 4 Working groups with Central Government

Information Assurance and Cyber Security were a topic of significant interest within central Government. Working closely with the relevant authorities, Atos and LOCOG provided the reassurances that the design and operation of the London 2012 systems offered the maximum protection against potential attack. This was a very successful joint approach that has proved that Government and Private Sector can jointly work together to deliver a successful programme on high profile programmes of national importance.

### 5 Conclusion

Ultimately the success of the Atos IT Security project has to be measured in terms of any impact to the Games from some form of cyber attack, and once again this approach has enabled another Olympic and Paralympic Games to pass without incident.



# Paper 4 – Online services overview

*Stuart Revell*

*Project Manager, ICT KTN, London 2012*

*E-mail: [stuart.revell@ictktn.org.uk](mailto:stuart.revell@ictktn.org.uk)*

Design of online services for major events has become increasingly challenging because of the adoption of different media formats with different bandwidth requirements, the rising consumption of content using mobile devices, the adoption of social media applications and the consumer demand for real-time information. The challenge is compounded by consumer expectations that information be synchronised. Simultaneous watching of content while at a live event or enhancing a live broadcast with a second screen is becoming commonplace.

A good example of this is the peak demand experienced on the BBC Network during the Games. Over a 24-hour period on the busiest Olympic day, total traffic to [www.bbc.co.uk](http://www.bbc.co.uk) exceeded that for the entire BBC coverage of all of the matches at FIFA World Cup 2010. On the busiest day of the Games, the BBC delivered 2.8 petabytes, with the peak traffic moment occurring when Bradley Wiggins won Gold with over 700 Gb/s. During the Games, the BBC provided four times Beijing's coverage transmitting 24 HD and SD streams, 2500 hours of coverage, on four screens.

The following sections will cover several aspects of the online London 2012 technology challenges and experience:

- 'Preparing for the Games' and the 'Games Times Usage' from a London Organising Committee of the Olympic and Paralympic Games perspective.
- BBC Online content, during the Games the BBC provided four times Beijing's coverage transmitting 24 live HD and SD streams, 2500 hours of coverage, on four screens.
- BBC partnership with NHK to deliver Super High Vision to several sites in the UK utilising the high-speed Janet fibre network.
- Atos Online Spectator Journey Planning: Getting the public to the Games on time and keeping the transport network balanced to ensure London continued to do business as usual.
- BT Social Media Monitoring – managing and using to optimise customer experience.



# Paper 4A – London 2012 website and mobile applications

David Finch<sup>1</sup> Chris Hudson<sup>2</sup>

<sup>1</sup>Senior Manager, Architecture and Security, LOCOG

<sup>2</sup>Internet Programme Manager

<http://uk.linkedin.com/pub/david-finch/2/a21/361/>

The [www.london2012.com](http://www.london2012.com) website was in place from an early stage in preparation for the Games and was a key strand in LOCOG's communications plan, being used to encourage engagement and provide news and updates on progress of the preparations. It was only in the final months before the Games that the focus switched to become much more Games-centric, with information on participating athletes, competition schedules and results coming to the fore.

## 1 Preparing for the Games

The LOCOG Website Operations team tracked usage of the London 2012 website for several years leading up to the Games and major milestones clearly stand out as peaks of activity. Figures 1 and 2 illustrate activity on the desktop version of the site from 2010 through to 2012: note the increasing scale from one chart to the next and the significance of the scale on Figure 3 and the Games time peak compared to the peaks experienced in the period leading up to the Games.

The levels of engagement in the years before the Games were extremely encouraging, however, the Games-Time activity clearly shows the necessity for the re-architected solution that was implemented, capable of handling demand an order of magnitude greater than anything seen before while simultaneously processing large volumes of new content, along with significantly increased levels of availability corresponding to the demand. Fig. 3 shows visits to the desktop version of the website from the start of 2010 through to the Olympic Games.

Overall during this timeframe the website was accessed by 170 million unique users.

## 2 Key Games-Time statistics

The period 21st July to 20th August 2012 represented the peak period of activity and during this period the following key statistics were captured from the Content Delivery Network and other monitoring tools relating to the desktop and mobile versions of [www.london2012.com](http://www.london2012.com) and the Results mobile app, see Table 1.

It should be noted that a range of different monitoring tools were used for the sites and allowance had to be made for discrepancies between the figures they reported. For example, the content delivery network provided statistics reflecting actual content delivered including any automatic refreshes, e.g. for updated results, whereas other analytics tools only captured the initial delivery of such a page.

A great deal of forecast modelling was carried out in order to determine appropriate requirements for the Games-Time Website project. At the outset, very complex modelling was carried out and some rather extreme figures determined for the website; however, with the benefits of additional technical expertise brought in to the project and seeing how actual web usage was developing as the Games approached, a more realistic 2 petabytes total data delivery was used as the Content Delivery Network 'budget' for the Games; this provided a reasonable safety margin over and above the actual 1.3 petabytes observed.

## 3 Mobile usage

LOCOG made available a number of mobile apps to cover the Olympic and Paralympic Games; see Table 2.

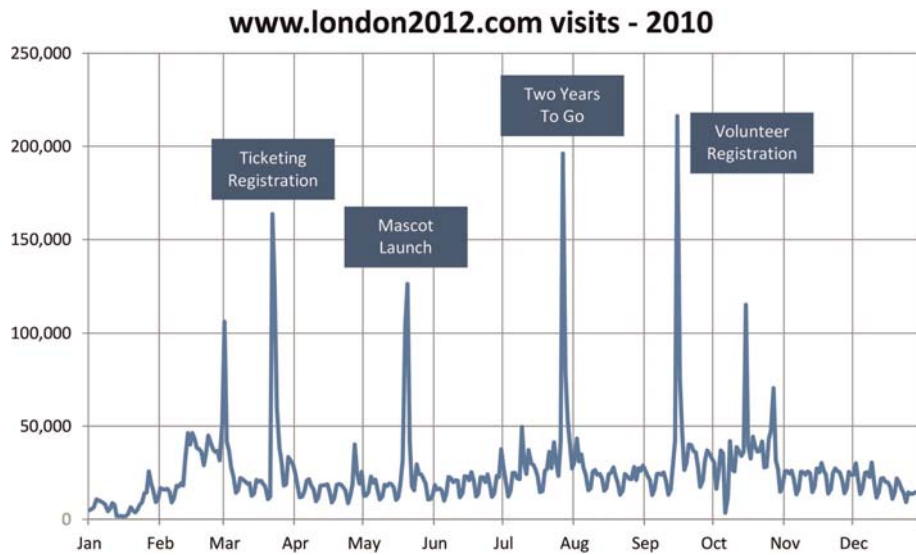


Figure 1 London 2012 Website visits per day, 2010



Figure 2 London 2012 Website visits per day, 2011

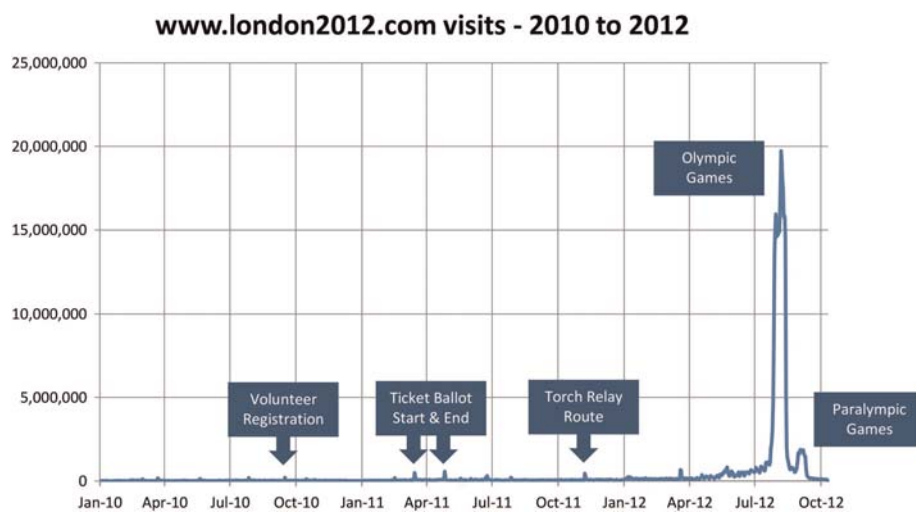


Figure 3 London 2012 Website visits per day, 2010 to Olympic and Paralympic Games

**Table 1** Key website statistics for the period of 21 July–20 August 2012

Description		Notes
Total data served	1.3 petabytes	
Total page views	4.73 billion	
Total object requests	116.5 billion	
Peak Hypertext Transfer Protocol requests per second	199k	
Unique users	109 million	
Peak concurrent users	493k	Desktop and mobile sites only Determined using a 5 s sampling rate
Peak pages per second	105k	Recorded on 3rd August 14:00 GMT, Federer against Del Potro Tennis semi-final: Argentina accounted for 6% of traffic
Average time on site	8 min	Desktop site only

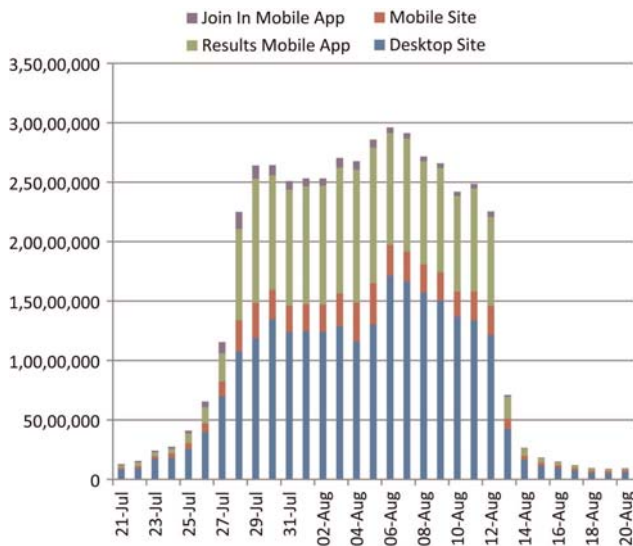
**Table 2**

<p>The Official London 2012 Join In app</p> 	<p>Released on 15 May 2012 as a mobile guide for the Olympic Torch Relay, Olympics, Paralympics, Ceremonies and many other cultural, city and community celebrations taking place in the UK, the purpose of this app was to help people plan their Games and share their experience through social media. The Join In app was supported on Android, iOS and Blackberry and recorded a total of 2.8 million downloads*</p>
<p>The Official London 2012 Results app</p> 	<p>Released on 4 July 2012, this app provided up-to-date news, schedules and results information for all Olympic and Paralympic sports, including live results updates. The Results app was supported on Android, iOS, Blackberry and Windows Phone 7 and recorded a total of 12 million downloads*</p>

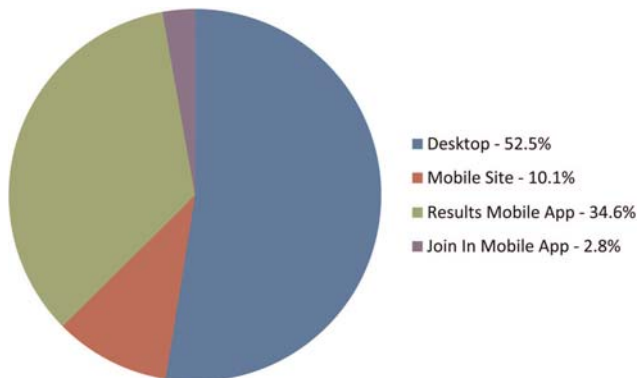
\*Downloads up to 12th August 2012, the day before the Olympics closing ceremony.

The expected demand from the mobile apps and the mobile site was particularly difficult to forecast because of the rapid increase in use of Smartphones in recent years; however, using a common approach for delivery of

content for desktop, mobile and mobile apps made highly detailed forecasting of each largely academic for infrastructure design purposes. Figure 4 shows the actual visits per day to the desktop, mobile site and the two



**Figure 4** Daily visits to the desktop, mobile and mobile apps sites, 21 July–20 August 2012



**Figure 5** Comparative use of the desktop, mobile and mobile apps sites, 21 July–20 August 2012

mobile apps during the key period of 21st July–20th August 2012.

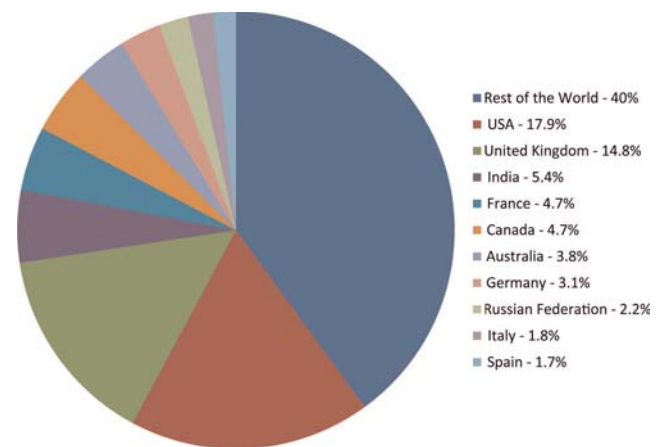
Overall, comparative usage of the different platforms during this period is shown in Fig. 5.

Unsurprisingly, the peak of 17,290 pages per second for the Results Mobile App occurred 10 minutes after the Men's

100 m final, at 21:25 GMT on 5th August, but otherwise peaks generally coincided with UK commuting patterns.

## 5 Worldwide appeal

In terms of where demand against the Olympic website was coming from, the following chart shows the ten countries recording the greatest levels of usage. The 'Rest of the World' figures are comprised of the remaining 224 unique countries that accessed the site: the fact that these accounted for 40% of total traffic clearly demonstrates the worldwide appeal of the Olympic Games. In addition, overnight, during the Games, the number of concurrent users was typically in the region of 170k, reflecting access from many different time zones (see Fig. 6).



**Figure 6** Website usage from around the World

## 6 End of the Games

With the end of the Games, website usage of course dropped dramatically. However, even in late September the desktop and mobile sites were still receiving 120k unique visitors per day and the Results mobile app was receiving 14k unique visitors per day.

The site will finally undergo decommissioning and be handed over to the IOC, so that a simplified version will continue beyond the lifetime of LOCOG.



# Paper 4B – Spectator Journey Planner: Getting you to the Games on Time

*Jonathan Shewell-Cooper*

*Business Consultant, Atos*

*E-mail: jonathan.shewell-cooper@atos.net*

## Purpose

The London 2012 transport plans were a key factor in London winning the right to host the 2012 Olympic Games and Paralympic Games. The task of providing transport for the Games had an impact on the whole of the UK transport sector and was delivered as a partnership between the Olympic Delivery Authority (ODA) and the transport authorities.

As the first Games where public transport was to be the prime method of accessing venues, where there would be no car parking at venues, the ODA was committed to giving spectators the information they needed to plan their journeys during the Games while at the same time keeping London and the UK moving in the context of dealing with the mismatch between supply and demand, and the desire to make transport part of the overall 'great' experience.

The Spectator Journey Planner (SJP) was commissioned by ODA Transport, as part of their Travel Demand Management (TDM) programme to support this key objective of informing spectators; while at the same time supporting other programmes such as the Games Network of Accessible Transport (GNAT).

## How the SJP was built

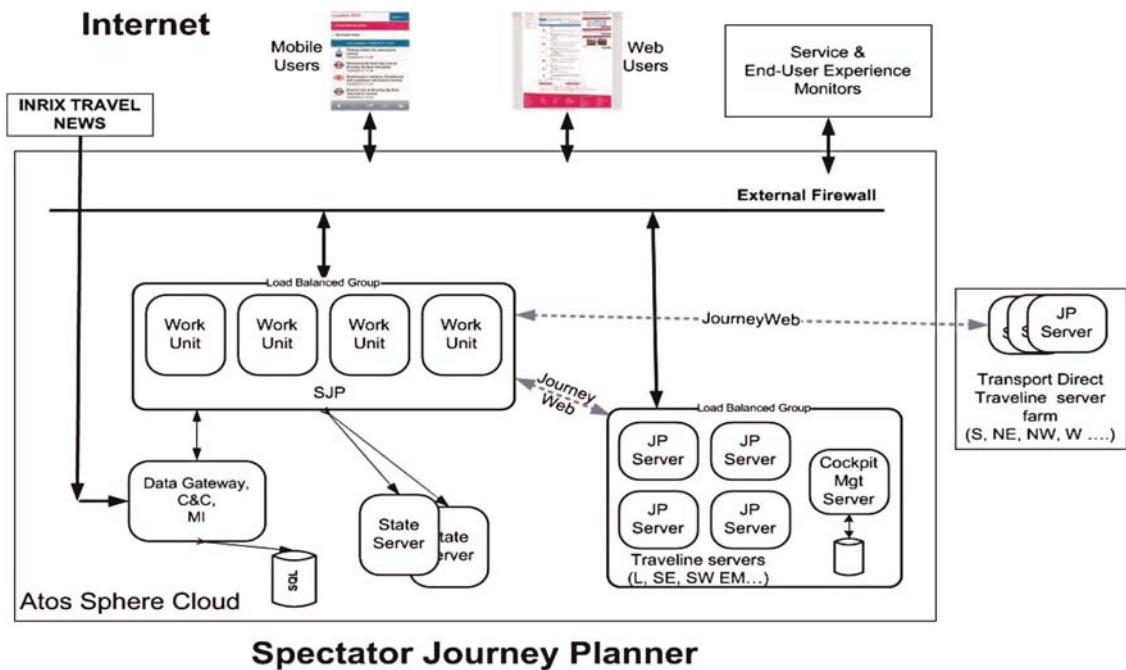
The SJP was built using the DfT's existing Transport Direct portal [[www.transportdirect.info/Web2/Home.aspx](http://www.transportdirect.info/Web2/Home.aspx)]. This gave the delivery a head start with a number of key elements such as Great Britain wide multi-modal journey planning. The Transport Direct approach of using the JourneyWeb [<http://www.dft.gov.uk/journeyweb/>] standard for distributed journey planning was continued into the SJP. This enabled the key Traveline [<http://traveline.info/>] data sets to also be used with SJP. The existing NaPTAN

[<http://www.dft.gov.uk/naptan/>] data sets were used to describe stops and link data to stops. The JourneyWeb interface was updated to v2.4 to ensure those features necessary for the SJP such as TDM, accessible journey planning and venue check constraints could be utilised.

A London 2012 specific user interface was developed to support spectator journey planning to, from and between venues. To ensure that spectators received journeys that gave them realistic journey times to venues; a venue data set was created that allowed potential delays because of security checks or simply crowding to be added as part of the journey. This dataset was created according to the NeTEX [[www.netex.org.uk](http://www.netex.org.uk)] standard and loaded into the journey planner. To support TDM, a venue-specific data set was created to influence the journey planning algorithm such that the journeys planned supported the agreed routes across London to venues and avoided the places where congestion was expected to be high.

To enable the SJP to describe the GNAT accessible routes to Games venues, an approach that combined the detailed routes through stations, already held by Transport for London (TfL) for London stops with a new data set that defined, for both stations and services in the rest of Great Britain, whether they met the accessibility standards set by the ODA was implemented. This new dataset that covered about 1100 stations, when loaded enabled the journey planner to be the first ever UK national planner for accessible journeys – providing accessible journeys for the whole of Great Britain.

By building on Transport Direct's car and cycle journey planners, which both understand time-based planning it was possible to add the Olympic Route Network (ORN) and Paralympic Route Network (PRN), so that the daily planned changes to the ORN could be reflected in the



**Figure 1** Spectator Journey Planner architecture overview

routes planned. Both planners are built using the Ordnance Survey's Integrated Transport Network (ITN), taking the Highways Agency HATRIS congestion data; and equivalent data sets from Traffic Scotland and Traffic Wales. The additional cycle network data were added using the principles of the Digital National Framework (DNF) [<http://www.dnf.org/>] which allowed DfT's cycle network data set, collected to the CycleNetXChange [<http://www.dft.gov.uk/CycleNetXchange/>] standard, to be laid over ITN.

To include the impact of the ORN on results, again using DNF principles, a data set was created that described the sections of the ORN and PRN – including the impact of road events, a specific dated measures data set – to describe specific features such as no right turn onto the ORN as a specific junction, and the level of impact on road speeds on roads in the vicinity of the ORN section. These enabled the existing road journey algorithms to plan journeys taking into account the ORN.

## Data challenge

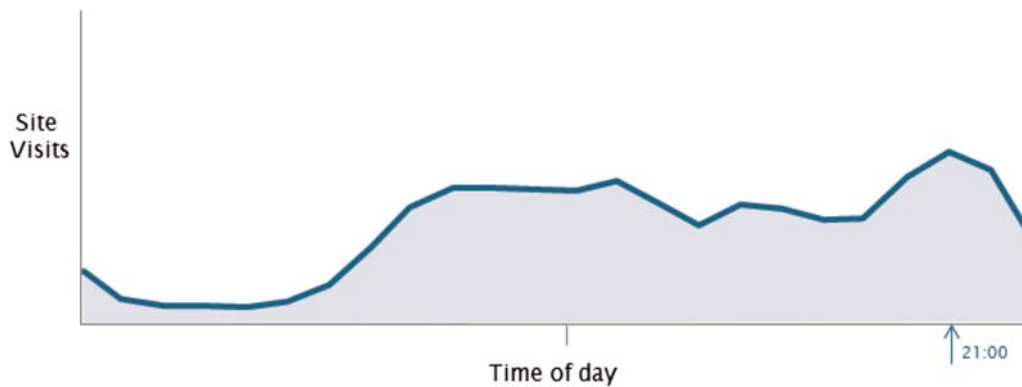
The key data challenge for the SJP was determined by the go live date, with national from anywhere journey planning required 12 months before the start of the Games being required to support the ticket sales process. Typically, public transport schedule data sets are only available at most three months in advance. In agreement with Traveline Board, the SJP went live in July 2011 with a mixture of the actual 2012 schedules from the trunk operators such as Network Rail and National Express and summer 2011 schedules rolled forward for local transport. The journey planner data were rebuilt over the year as more operators published their Games time schedules.

## Real-time layer

During Games time a real-time layer was added to the journey planner. This was created again using a mixture of existing technology used by the TfL Real-Time team and some Traveline regions and the Transport Direct INRIX Travel News feed. For the Games this was extended to ensure that through the creation of a subscription SIRI-SX [<http://www.kizoom.com/standards/siri/schema/schemas.htm>] feed all the underlying Travelines were able to integrate a consistent set of news to journeys. In addition, for the SJP, news was linked to the venues so that spectators traveling to and from events could see specific travel advice, from the Transport Coordination Centre, for their venue overlay. As there was little disruption during the Games this was not a heavily used facility; but on the days when there was some disruption there was significant use of travel news from mobile devices.

## Capacity modelling

The SJP was a first so there was no experience from previous Games on which to model its usage. Atos worked with the ODA and DfT to develop a capacity model for the 15-month life of the application based on spectator numbers from different regions of the UK, projected tickets sales and so on. It was clear that the usage of the system would vary greatly over 15 months. Atos therefore needed to adapt to the mature Transport Direct ASP.Net application to create a scalable but still high availability SJP (see Fig. 1). The first key change was to port the application so that it ran as a set of identical 'work units' that could be deployed on virtual machines as capacity required. These were deployed in the Atos Sphere™ cloud across multiple data centres. To manage session state across the work units the application was



**Figure 2** Spectator Journey Planner usage pattern showing the 21:00 daily peak

modified from a central session database to use a commercial off the shelf product that provided a distributed in-memory based service that still enabled session state to be accessed from each work unit and still maintain response times and availability.

## Integration to London 2012

The SJP was developed as a sub-domain from the main London2012 domain but had the same brand styling as the main site, as well as other standards such as site accessibility, so as to provide a seamless transition between the sites. This was achieved through the SJP consuming the style sheets, menu structure and assets from the main London 2012 sites for both the initial release and for the Games Time Website rebranding. Through the use of Universal Resource Locator parameters, such as venue or travel date, the main London 2012 site, the London 2012 Join In App and third party services such as TfL's telephone-based journey planner linked to the SJP, both the main and mobile site, ensuring that users did not need to reselect details within the SJP.

## Usage patterns Olympics and Paralympics

The overall usage of the SJP:

- Just short of 4 million sessions
- Almost 2.75 million unique users (about 75% of all ticket holders)
- 1.3 million journeys planned, of which 30% were return journeys
- Less than 0.1% of 'sorry' or failed requests.

Fig. 2 shows what was a consistent pattern of daily usage that peaked each day, except the day of the opening ceremony, at about 9 pm. This is very different from the usual daily journey planning peaks, which are more associated with getting home from work. Despite creating the site to support journey planning in advance of the Games the major usage of the site was during the Games period.

Over 95% of journeys planned were public transport journeys, with car and cycle journeys to the venue making up

the rest. This percentage was even higher during the Paralympics. However, the Transport Direct system calculated four times the normal level of car journey plans during the first week of ORN operation. This demonstrates a division between spectator journeys and background demand; spectators focused on public transport journeys to the Games, other users were concerned about how the ORN would impact their journeys.

Of the public transport journeys planned about 2% were from users requesting accessible journeys. This figure was a little higher during the Paralympics but is generally in line with what was expected.

Overall, 70% of journeys were planned from stations – both rail and underground – with only just over 11% from Postcodes; this may reflect how travellers think about planning public transport journeys. On the mobile version over 25% of journeys were planned from 'My Location' demonstrating the rise in context aware capabilities. During the Olympics over 45% of journeys were to or from Olympic Park venues; which was the venue with the largest capacity.

Overall, during the Games around 30% of access was from a mobile device [As measured by Google Analytics] – of which nearly 80% was iPad and iPhone.

*One final fact:* the busiest hour of the Olympics was at 21:00 on 30 July and the busiest hour of the Paralympics was exactly one month later at 21:00 on 30 August!

## Legacy

The legacy of the SJP will see work in the journey planning industry to build on the use of TDM to assist in the management of passenger flow through infrastructure with a limited capacity, to develop better accessible journey planning and improve transport information, both in advance and in real time, for larger events in the future. Alongside this, successful deployment of the application in the cloud will encourage other areas of government to investigate the benefits cloud services will bring to them.

# Paper 4C – BT, social media monitoring

Andrew Parker

Head of Service, BT London 2012 Programme  
E-mail: [andrew.s.parker@bt.com](mailto:andrew.s.parker@bt.com)

## 1 Social media monitoring

With the continued pace of the digital age, and the associated rise in both public and corporate use of social media channels, the 2012 Olympics were faced with new challenges in the delivery and management of technology services.

The potential for what was seen as the ‘perfect storm’ of issues in the consumption of technology-based services

during the peak of the 2012 Olympic and Paralympic Games was recognised by the 2012 technology team in the lead up to the Games.

With the concentrated delivery of Wi-Fi and mobile network services in and around the Olympic Park and the anticipated proliferation of mobile applications related to the Games, the potential for congestion and or other problems across one or more of these components was always a risk. In the event that this should occur it was

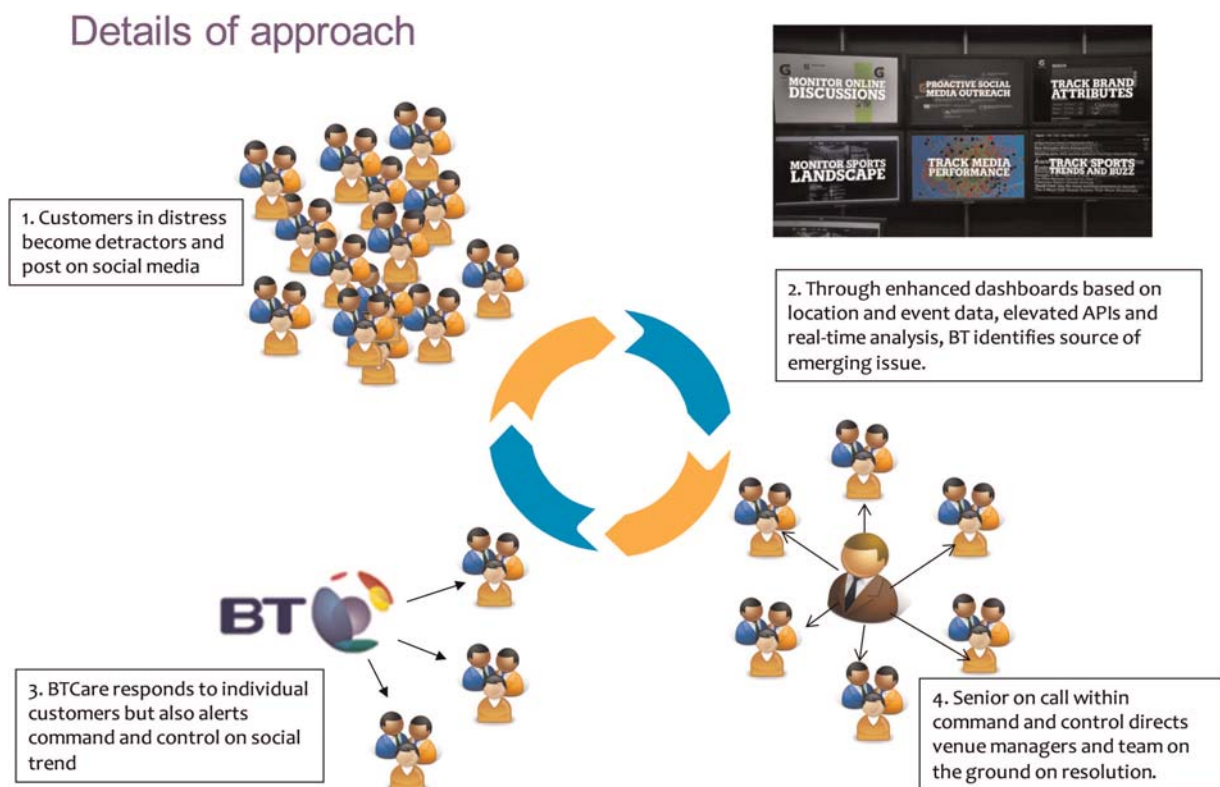


Figure 1 Details of approach

critical that BT and other technology partners had 'early warning' of potential issues.

It was recognised that the public use of social media channels as a sounding board for sharing such issues should be given attention as part of the overall integrated service and operational model.

BT engaged the services of an existing partner (Synthesio) from within its BT Retail operation in order to assist in developing an approach to 'social media monitoring' as part of its operational horizon scanning capability within the LOCOG Technology Operations Centre (TOC). Through the configuration of a complex and comprehensive series of search strings, working together with and utilising Synthesio's monitoring tooling capability, BT developed an additional set of eyes and ears in order to provide early warning of the potential 'perfect storm' scenario; see diagram on previous page (see Fig. 1).

Taking this configuration, analysts were deployed in the TOC during the Games period in order to monitor dashboards displaying the output of the monitoring, utilising specialist techniques in following up on any

activity worthy of attention. This was then used to report potential issues to the wider operational teams and to provide summary reporting at the end of each operational shift.

As a result of the careful planning and forecasting that had underpinned the delivery of services to the Games, the reality was that there were very few issues of significance throughout the Games period, and as a result the traffic coming through the social media channels in respect of this was limited. However, the power that the integration of such a channel as an operational tool can have in the delivery of publicly visible technology services. Indeed, the team was able to flex the use of this capability to focus on very specific events as they occurred, adapting 'listening' criteria in real time to understand the impact of these events on services.

With the continued uptake in the use of social media by the general public, having the ability to identify potential issues early, follow trends in public sentiment and seeing and being able to respond directly to individual 'verbatim' messages is something that will become a must in any service and operational model.



# Paper 4D – Online Content – 2012 – A Big Year for the BBC

*Ben Ross*

*Distribution Manager, BBC Distribution  
E-mail: Ben.Ross@bbc.co.uk*

## 1 2012 – A Big Year for the BBC

The BBC has long known that 2012 would be a very big year for television and radio. Not only the Summer of Sport but also the Queen's Diamond Jubilee and the Torch Relay meant that ensuring that all its programming 'held-together' was at the forefront of its collective mind. It was with this in mind that strategic plans were laid out to ensure that our connected services would cohere and deliver new services alongside the BBC's traditional linear, broadcast channels, creating for the viewer, listener and user an experience second-to-none, and one that allowed them to get closer to the action than ever before.

The Connected Four Screen Strategy, unveiled in January 2011, ensures that the BBC's non-linear services are distinct, high-quality, straightforward to understand and easy to use across each of the 'four connected screens' – personal computer (PC), mobile, connected television (TV) and tablet.

The BBC's flagship television channels offered an excellent service, with editors making decisions about which events to show based on the profile of a particular sport, the participants involved (particularly if Team GB athletes featured), medal opportunities and a host of other factors. For many, this service allowed a fantastic 'sit-back' offering, where a viewer could be sure of never missing the highlights. However, this was the first 'digital Olympics', where almost every area in the UK is digital-only for television, and where a large majority of homes have a computer and broadband, enabling them to tap into the broader offering the BBC has online. The BBC knew that it would not be good enough to make one-size-fits-all choices, without any way of routing around these editorial decisions – which, after all, are simply one view of what a viewer would be interested in. Instead, the BBC determined that it must enable licence fee payers to view what they wanted, when they wanted it.

## 2 The Olympics '48 additional broadcast channels

The launch of 24 additional standard definition channels and 24 additional high definition (HD) channels, on satellite and cable allowed viewers with those services to watch live coverage of every session from every event on their televisions, delivering on the BBC's promise to 'never miss a moment'. If the Olympic Broadcasting Service filmed it, the BBC enabled its licence fee payers to watch it – on satellite, on cable and online. Achieving this required a huge amount of capacity – with nine additional satellite transponders (more than the BBC uses for all its normal channels put together!), while making use of the latest encoding standards to ensure that picture and audio quality did not fall below that which viewers expect.

As the BBC uses 'statistical multiplexing', where groups of channels are dynamically allocated capacity according to how difficult the material being broadcast is to encode, particular attention needed to be paid to those sports that feature complicated visuals – such as water sports. Although the number of streams only reached its peak level on a single day, we made use of all the transponders for the duration of the Games, enabling the fewest possible number of services to share the same transponder, maximising the quality of statistically multiplexed services.

## 3 The BBC Sport App, available on Android and iOS and via a web bookmark on Blackberry smartphones exemplified the Four-Screen Strategy

The BBC Sport App, available on Android, iOS and Blackberry smartphones exemplified the Four-Screen

Strategy, with a best-of-breed experience available on mobile phones. It provided all the up to 24 streams of live video coverage, detailed schedule and results pages and daily news stories. Alongside full live streaming, catch-up coverage and highlights, the app offered facts, statistics and information for every athlete, country and sport.

Although the mobile browser version of the BBC Sports website offers a rich content offering, the App offered a native experience to users of the relevant smartphone platforms. Rather than taking a one-screen-size-fits-all approach, the aim was to recognise the different ways in which the different screens are used, including mobile use on-the-go, and as a second-screen accompaniment to television viewing. As a second-screen, the BBC Sport App offered unobtrusive additional information that enhanced the viewing experience without interrupting or taking up space on the main screen.

On connected televisions, initially launched on Virgin Media's TiVo platform and a number of Smart TVs, the Sports App also enabled a rich viewing experience accessible directly from the remote control. Offering a next-generation red-button experience, the emphasis was on getting viewers directly to the action they want, accompanied by rich background information no matter which event they tune in to.

For the duration of the Olympics, the Games 'took over' the BBC Sport App, showcasing its dynamic capabilities. Apps built on standards-based internet technologies can be rolled out to other platforms, and are able to 'grow' to

encompass special events, including using special menus to surface events that the user might want to access more quickly. Delivering live video using Hypertext Transfer Protocol (HTTP) – the same way web pages are delivered to your browser – gave us much greater distribution capacity by using the existing caches and standard HTTP infrastructure. This allowed users to receive high quality streaming video even when we were delivering the peaks around the big Team GB medal moments.

We took the 24 HD feeds at  $1920 \times 1080i$  as used on our broadcast streams and repurposed these for online, employing eight h.264 profiles ranging from 54 Kbps at  $224 \times 126$  to 3500 Kbps at  $1280 \times 720$ . By comparison, the broadcast streams used up to 18 Mbps. We served these in several different Adaptive Bit Rate sets targeted at different screen resolutions, device capability and network throughput, using two flavours of chunked HTTP delivery: Apple HLS and Adobe HDS. We also delivered using Real Time Messaging Protocol – an older streaming protocol – for some legacy devices (see Fig. 1).

#### 4 Linked Data

Metadata are fundamental to the delivery of the BBC's online offer, and for the Olympics BBC Sport and Future Media took linked data to the next level. By connecting the relevant data – from starting line-ups to medals, results to records and video assets themselves – to 'real-world things' the BBC was able to dynamically publish a page for every athlete, event, discipline, country and venue.

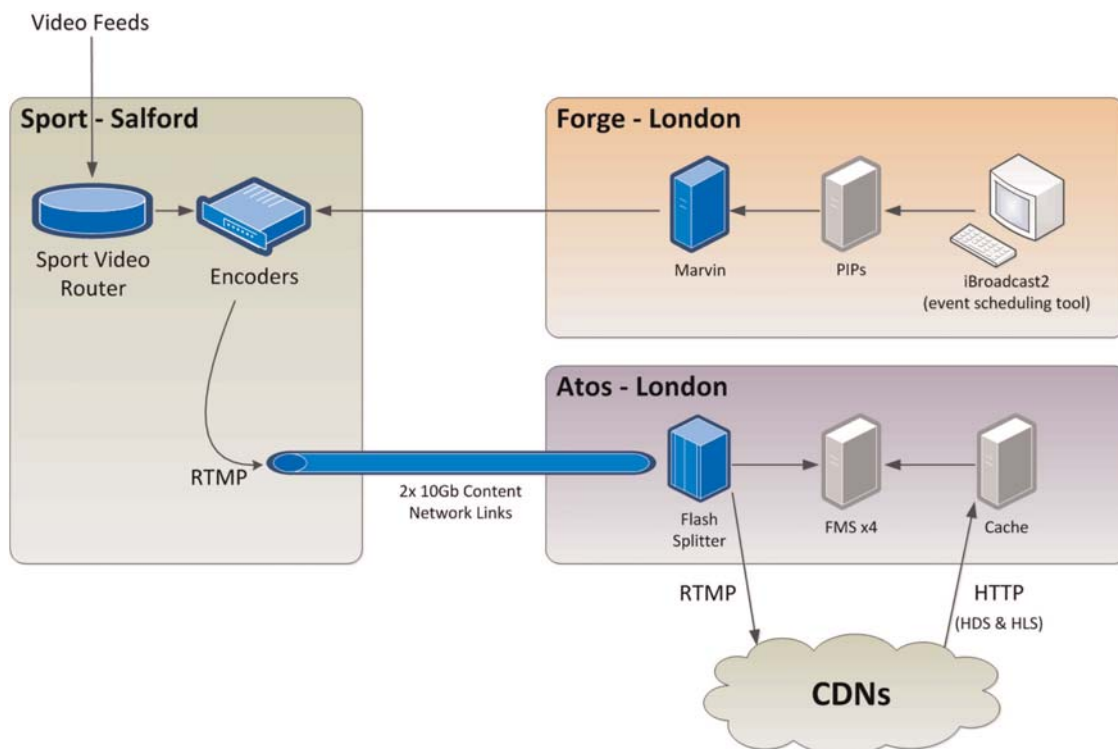


Figure 1 BBC system architecture for delivering on-line video

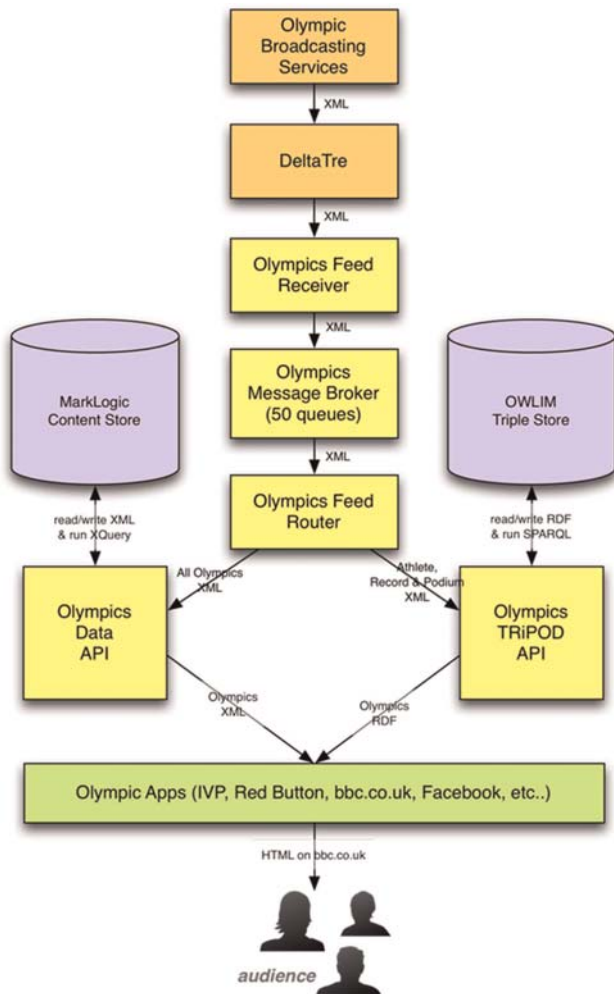


Figure 2 BBC Linked Data architecture

The data you get out are only as good as what you put in, however, so creating these linked data was not simply a matter of setting an algorithm going and seeing what it spits out.

The London 2012 Olympics were the first where a combined video and results data feed (the Broadcast Data Feed (BDF)) was made available. The BDF provides Olympic Data Feed (ODF) results and statistics from London Organising Committee of the Olympic and Paralympic Games, plus video data from Olympic Broadcasting Service. In practical terms, this means that not only did we know the live results for every moment of every event, but we also knew which video streams were showing the action at that time.

The BBC subscribed to the BDF and received it via data provider Deltatre Media Ltd. The raw BDF was huge and contained much more data than the BBC needed. In addition, the feed was state-dependent; hence it required a

relatively complex receiving system which knew how to apply updates as they arrived. Deltatre transformed the complex and state-dependent feed into a simpler, stateless feed, which provided the BBC with just the data needed to power the online products.

While source data were generated from the Olympic Broadcasters' Data Feed (BDF) via the Olympic Data Application Programming Interface, additional editorial 'real-human' information was added by teams at the International Broadcast Centre (in the Olympic Park), in Media City UK and at venues around the country. These enabled the creation of 'chapter points' within video streams, enabling users to richly navigate the available media rather than relying on just a timeline or information known prior to the event, such as the sport or competing nations. It does not stop there – because the data is linked to 'real-world things' every record broken, every disqualification or false start, every personal best or against-the-odds comeback is linked instantly to the athlete or country, event or discipline and assets appear on the relevant pages, no matter in what medium it appears.

Linked data have been firmly embedded as part of the BBC's 'Olympics legacy'. The BBC is investigating how to roll this out into the rest of Sports and News, and further down the line across other genres and areas of production. It will be fundamental to creating the next-generation multi-platform-native offering (see Fig. 2).

## 5 Live Interactive Video Player (IVP)

On the PC, the live, interactive video player was the BBC's flagship Olympics product for watching video, whether live or on-demand. The live, interactive video player allowed viewers to watch every sport.

The IVP allowed viewers to watch every sport available live and on demand in HD quality on every day of the Games. This required up to 24 live streams at any time, to cover the maximum number of simultaneous events as they happened. A fully interactive timeline enabled users to pause and rewind live video or jump straight to key moments they may have missed by using chapter markers as defined by the Linked Data, both from automatically ingested sources and as input by human editors. Alerts for the key events that have happened or are coming up ensured viewers did not miss moments that matter to them – and overlays of extra facts and info on the sports and competitors alongside the video being watched gave users all the context they needed to understand an event, even those that were completely new to them.



# Paper 4E – Super Hi-Vision – The BBC and NHK

John Zubrzycki<sup>1</sup> Alex Russell<sup>2</sup> Yoshiaki Shishikui<sup>3</sup>

<sup>1</sup>Principal Technologist, BBC Research & Development

<sup>2</sup>Senior Commercial Manager, BBC Distribution

<sup>3</sup>Head of Advanced Television Systems, NHK Science and Technical Research Labs

E-mail: John.Zubrzycki@rd.bbc.co.uk; Alex.Russell@bbc.co.uk; shishikui.y-hw@nhk.or.jp

## 1 Super Hi-Vision – the BBC and NHK

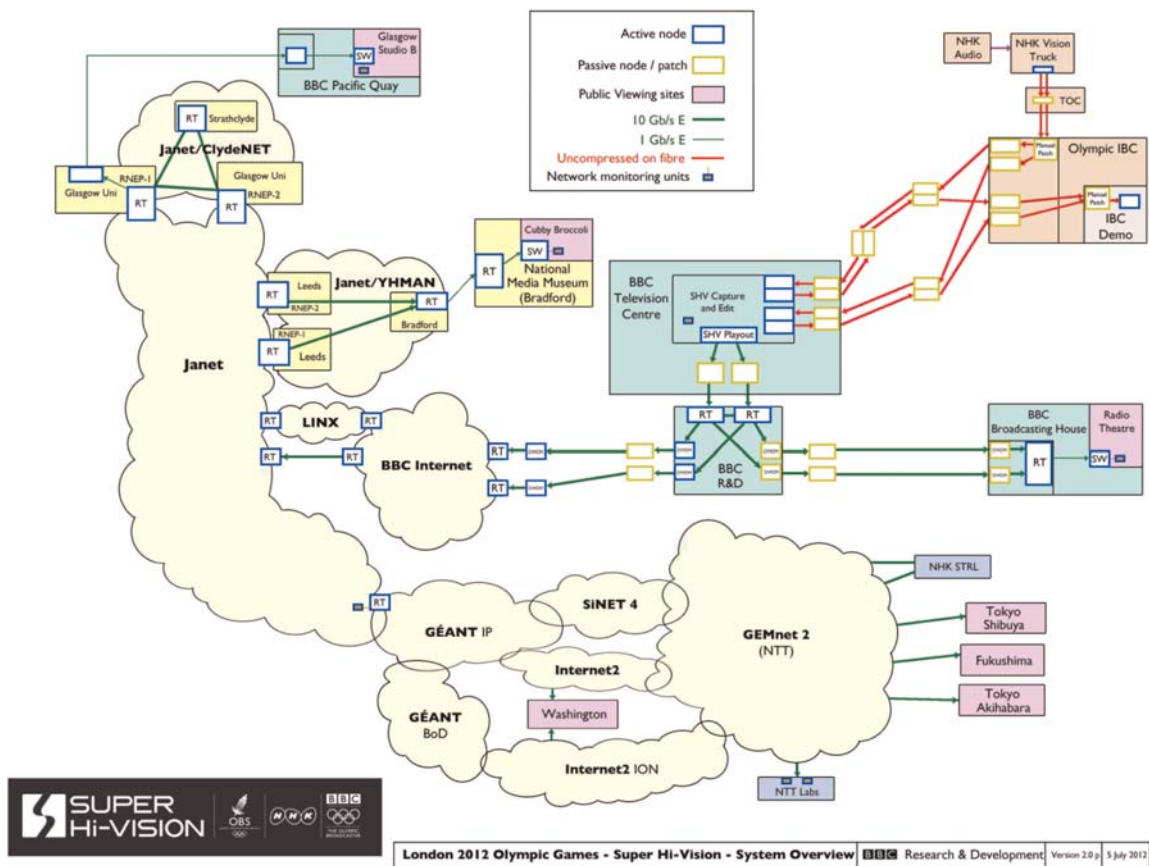
The Olympic Games has always been one of the great television (TV) 'firsts'. The London 1948 Games were the first to be televised in people's homes, in 1964 Tokyo brought colour to The Games and in 1984 the Los Angeles Games were the first to be captured in High Definition. The London 2012 Games will be remembered as the first Super Hi-Vision (SHV) Olympics thanks to the on-going partnership between BBC Research and Development (R&D) and NHK (the Japanese public broadcaster). SHV has 16 times as many pixels as HDTV making a picture with 7680 pixels across by 4320 pixels down. It was displayed on 8-m wide screens, accompanied by a 22.2 multichannel three-dimensional sound system.

BBC R&D has been collaborating with NHK Science and Technology Research Labs on SHV for 4 years. NHK themselves have been developing the system since the mid-1990s. Their aim was to produce a TV system where the resolution matches that of the eye when the screen is big enough to fill your field-of-view.

BBC Sport used the Olympics as a high tech showcase, and SHV was selected as one of the ideas. BBC Sport set up a project where they worked with NHK and BBC R&D to bring the SHV showcase to fruition. NHK brought over to the UK almost every piece of SHV production equipment that exists together with projectors and sound systems to equip three SHV theatres around the UK. These were at BBC Scotland's Pacific Quay, the Bradford National Media Museum and BBC Broadcasting House together with one at the Olympic park with a Panasonic 145-in 8 k plasma display. Hourly screenings were scheduled for which tickets were available free of charge from the BBC or the Media Museum. More detail of the equipping of the viewing sites is included later.

NHK had the only three operational SHV Ikegami cameras in existence in the Olympic park, these were equipped with Canon and Fujinon lenses, whose output was sent back to an Outside Broadcast operation. The 24 Gb/s uncompressed output feed was transmitted over eight optical fibre wavelengths (with a spare fibre standing by) to a special SHV Production Centre at BBC Television Centre. Here, the footage was ingested, edited into packages on BUG and Astrodesigns edit systems (with an off-line edit created in high definition (HD), and then conformed to give the full SHV programme package). It could be viewed in a dedicated viewing theatre (on a Sharp 85-in 8 k liquid crystal display (LCD)) before being stored on a recorder based on 16 individual P2 (HD solid-state) recorders multiplexed together. To enable a fast-turnaround of events, two duplicate edit systems were used. During playout, from a pair of P2-based players (main and reserve), the footage was compressed down to 280 Mb/s transport stream (TS) – actually two TSs, as 280 Mb/s is too big for only one! The TSs were then converted to Internet Protocol (IP) streams with FEC totalling 350 Mb/s. Everything was also doubled up to have both main and reserve coding and transmission systems, and dual-redundant fibre paths from the BBC R&D network, via the BBC/Atos network to Janet (see below). Thus, the entire system was designed to be as resilient as possible to support the Games and ensure that various public and private demonstrations across multiple venues all went without a hitch.

The transmissions to Glasgow and Bradford were carried to the theatres over Janet, who viewed the exercise as an opportunity to provide practical experience of the provision of capacity for very-high data-rate time-critical and quality-critical services. Janet is a private, government funded UK Internet Protocol (IP) network offering high bandwidth IP connectivity and private bandwidth channels to academic institutions and research houses. Janet connects to other



**Figure 1** Super Hi-Vision Contribution and Distribution System Overview

worldwide research networks and currently has a backbone of 100 Gb/s along with over 18 million users. Janet's partners YHMAN and ClydeNET provided the gateways to the venues in Bradford and Glasgow, respectively. The GÉANT, Internet2, SiNET4 and GEMnet2 research networks, coordinated by NTT, were used for the links to the USA and on to Japan, with one viewing site in Washington, two in Tokyo and one in Fukushima. The diagram above gives an overview of the whole system (see Fig. 1).

At the viewing theatres, the signal was decoded and displayed on 250 or 300 inch screens using JVC projectors with 8 k resolution and the audio sent to the 22.2-channel audio system. At each venue, NHK provided equipment to unpack the signal from the transport streams transmitted over the IP network, servers able to record both the raw transport stream and the uncompressed SHV, decoders, audio amplifiers and presentation router, in addition to the projectors and Bose audio system. For the UK venues, BBC R&D provided a communication system based on IP phones and HD video conferencing using BBC R&D's brand-new Stagebox real-time video-over-IP system, as well as electrical power distribution and volunteer technical staffing. The Media Museum and BBC also provided volunteers to act as guides and explainers for exhibitions, which were mounted to show the history of TV

broadcasting at the Olympics, at each of the UK venues (see Fig. 2).

There were usually 7 showings per day for the full duration of the Games and the preceding week on the hour from 12 noon. They consisted of nominally 40 min programmes, one with pre-recorded content for the preceding week and five versions of Games content throughout the Games for the UK/US and Olympic Park audience and six versions for the Japanese audience.



**Figure 2** Super High Vision viewing theatre at BBC Broadcasting House, London

In addition, the opening and closing ceremonies were transmitted live, as were two swimming events. The UK audiences totalled over 14,700 people across the three UK sites and over 200,000 people in Japan, plus 4000 people in the Olympic Park and 500 invited guests in the USA.

The project was a huge success; not only did the BBC and NHK show that IP networks can be made to reliably carry high bit rate time critical video and audio (if the network links are very carefully configured), but several thousands of people got to experience 'the best seat in the house' and witness a truly exceptional Hi-Vision view of the Games.



# Paper 5 – Managing the Delivery of Games Information and Communication Technologies: an overview

*Gerry Pennell OBE*

Chief Information Officer, LOCOG  
E-mail: gerrypennell@gmail.com

The scale of the delivery and the wide range of technologies and suppliers required to stage an Olympic and Paralympic Games on time and to quality is exceptionally demanding from an overall management and governance perspective.

For London 2012, a combination of approaches was adopted and integrated through some central governance and oversight mechanisms.

## 1 Introduction

This paper provides an overview of the management approaches adopted to deliver the technology required to stage the London 2012 Olympic and Paralympic Games.

It excludes deployment and operations, a related challenge, which is the topic of a separate paper [Paper 6 – Operating the Technology at the Games: an overview].

## 2 Scope

The focus of this paper is on the implementation of the set of systems and technologies that was required by the Organising Committee to operate the Games themselves, to measure and record the sporting performance(s) and to distribute that data to the many different audiences that consumed it.

In summary, LOCOG working with its partners and suppliers implemented all the following:

- A set of applications to assist the management of the Games: for example, Arrivals and Departures, Medical Encounters, a Rate Card portal and issues tracking and management system.

- A set of on-venue results applications from Omega and their sub-contractors, integrated with the relevant timing and scoring devices on venue and with a central information distribution system developed by Atos.

- A Commentator Information System, new for London, developed by Atos alongside a browser-based myInfo+ system primarily targeted at the written media and available on their own devices (new for London).

- A set of data-feeds to enable broadcasters, press agencies and others to use the results information delivered using the new Olympic Data Format and to update their own web-sites and applications.

- The organising committee's own web-site, content distribution system and associated mobile applications on four platforms. The first Games where real-time results were available across these channels for all sports.

- Scoreboards, videoboards and other audio-visual technologies on venue not least to support LOCOG's drive to enhance the presentation of Sports for spectators.

- A converged IP network delivered by BT to support voice and data between all competition and non-competition venues used in the Games.

- A dedicated trunked digital radio network provided by Airwave plus some specific radio technologies to support local requirements, not least for some of the road events.

Excluded from the organising committee's direct responsibilities was IT used by providers of operational or

marketing services as part of their own operations; for example, the ticketing systems and web-site implemented by Ticketmaster.

### 3 Overall philosophy and management approach

The organising committee – LOCOG – is a temporary organisation and, in addition, a number of the technology suppliers were mandated by the IOC. An essentially out-sourced approach was taken to delivery with the technology department within LOCOG providing the overall management and co-ordination, including ownership of requirements and architecture and overall operational responsibility via the Technology Operations Centre (TOC) – refer to the paper ‘Operating the Technology at the Games: an overview’.

There were in excess of 60 contracts with a wide range of suppliers ranging from the very large (BT) to a number of small and medium-sized enterprises providing specific pieces of bespoke software, for example, Trinity Expert Systems delivered the Competition Schedule Management system.

Each contract and supplier relationship had a named owner within the organising committee with the CIO acting as the point of escalation. In addition, the major providers attended a Joint Review Board on a monthly basis throughout the lifetime of the delivery programme. This Board was a vehicle to ensure effective communication rather than joint decision making, but it ensured that the providers were fully briefed on progress at all stages.

LOCOG Technology was structured around primary delivery areas as follows with two cross-functional areas:

- A Technology Programme Office (TPO) to ensure consistent on-time project delivery across all areas and to interface to central project management in LOCOG operations. The TPO implemented a milestone-based dashboard and graphical reporting system into which all 37 project streams reported and which was reviewed on a fortnightly basis by the CIO and the Technology Leadership Team.
- A Technology Operational Readiness (TOR) delivery plan was established to ensure that the wider technology team had what it needed to operate including accreditation, transport,

catering, volunteers and so on. At Games-time, this function proved to be critical to success (see Fig. 1).

### 4 The key challenges and the Organising Committee’s response

All large-scale systems integration and deployment projects, especially where significant innovation is involved, face substantial technical and organisational challenges.

Somewhat unique to the context of the Olympic Games were the following:

#### 4.1 Requirements time-line

Technology engineering lead times tend to be substantially longer than the lead times required to plan and construct a typical part of the operation, which means that frequently requirements are being finalised in advance of complete operational clarity – operational planning lifecycles tending to be relatively late.

In this scenario, classical approaches to requirements elicitation and agreement tend not to work and, instead, much of the development advanced on the basis of assumptions – requiring adjustment and late change subsequent in the process. Recognition of the requirement to deal flexibly with late change was embedded in many aspects of the overall project planning.

#### 4.2 Implementation approach

Whereas, in a normal corporate environment, functionality can be deployed in phases and then tweaked and adjusted and teething difficulties resolved, this is not a practical approach when, for the vast majority of the life of the organising committee, no events are being managed and there is no live operation.

In response, the organising committee put a heavy emphasis on Test Events as a proving ground for its operations and, alongside testing the Field of Play, a key driver was the need to test as much of the technology as possible. Specifically this included all the timing, scoring and results systems for all Olympic sports but some technologies, for example, electronic access control, were only tested at some events. In addition, two major operational exercises – the ‘Technical



Figure 1 LOCOG Technology Management structure

Rehearsals' were implemented to trial both the technology and the operation under pressure.

Alongside test events, a heavy emphasis was placed on functional testing (by LOCOG) as well as technical testing (led by Atos) in the Integration and Test Lab in Canary Wharf – effectively the 'Olympic Games in a room'.

### 4.3 Fixed timeline

It was clearly not possible to delay the start of the Olympic Games and, as a consequence, the general project management approach was milestone driven and time-boxed in approach. The test event programme was beneficial in providing earlier deadlines for key deliveries from a number of our partners and suppliers.

### 4.4 Innovation against risk minimisation

Given the mission-critical nature of most of the technology, in principle the organising committee sought to avoid innovation to minimise risk. In practice, at London 2012, a significant amount of innovation was inevitably driven by changing demands from users and technology shifts.

### 4.5 Consumerisation of technology

The most significant change in the technology landscape since Beijing 2008 was the arrival of the smartphone and related devices – with corresponding increased expectations

from consumers, athletes, journalists and other user groups. A number of responses were required:

- The organising committee commissioned the construction of mobile apps on four mobile phone platforms but the bigger challenge was provision of the supporting infrastructure to allow data to be delivered – refer to the sections on Online Services.
- The organising committee worked closely with the Mobile Network industry in the UK forming an organisation called the Joint Olympic Operators Group to provide shared infrastructure in the Olympic Park and elsewhere.
- BT, in conjunction with Cisco, provided a very large high-density Wi-Fi system in the Olympic Park.
- Wi-Fi services were provided for Athletes across the Athletes Village and in many of the Athlete lounges within the competition venues.
- Wi-Fi was made available for operational users in many back-office areas, alongside substantial in-building coverage on the 3G network via O2.
- Project management and co-ordination of various Wi-Fi solutions was a challenge in itself and is further discussed in the papers on Wireless and Mobile Services.



# Paper 5A – BT Technology Project Management for right first time

*Tim Boden*

Technology Director, BT London 2012 Programme  
E-mail: [tim.boden@bt.com](mailto:tim.boden@bt.com)

## 1 Introduction

Delivering a programme as complex as the Olympic Games requires that you put in place strong delivery controls coupled with the right structures to enable delivery right first time. However, the challenge facing the London 2012 team was quite unique in that it provided a mixture of an immovable deadline, highly visible services allowing no change in scope and an environment with almost constant change.

When coupled with the potential brand impact of failure, this then is a potent mix. In order to ensure delivery, the team created a strand structure to ensure end-to-end delivery, while providing local control through venue management. This paper describes how these mechanisms worked as illustrated in the diagram below (see Fig. 1).

## 2 Delivery strands

The delivery programme was broken down into a series of delivery strands covering the main areas of delivery, namely:

- Wide Area Network (WAN),
- Local Area Network (LAN),
- Wireless Networks,
- Fixed Telephony (IPT),
- Mobile Telephony,
- Internet/Security,
- Cabling Infrastructure,

- CATV,
- BT Portfolio/Regulated Services.

Each of these had a project manager responsible for end-to-end delivery of the services managed by that strand, together with their design, processes and service tooling. Their responsibility was to build any centralised infrastructure required to support those services, and to create the approach that would allow efficient roll-out of services to multiple venues simultaneously, in a short timescale.

## 3 Strand assurance

Working under the project manager was a technical design authority, who had control of the architecture and detailed design of the services. The TDA was responsible for ensuring that the services were capable of meeting their requirements. This was achieved using a two stage critical design approach that drew upon the principles of TOGAF illustrated below (see Fig. 2).

The first phase was Critical Design Review (CDR). Its purpose was to ensure coherency of the solution architecture for the services proposed, that is, the service not just the technology. Its focus was not on validating that the solution performs as required (which is that of the testing functions), but instead required the TDA to present their solution through views that examine softer issues, namely:

- *Requirements*: Looking at known non-compliances and test coverage holes;
- *Lifecycle*: Ensuring that components were not in the sunrise or sunset of their lifecycle;

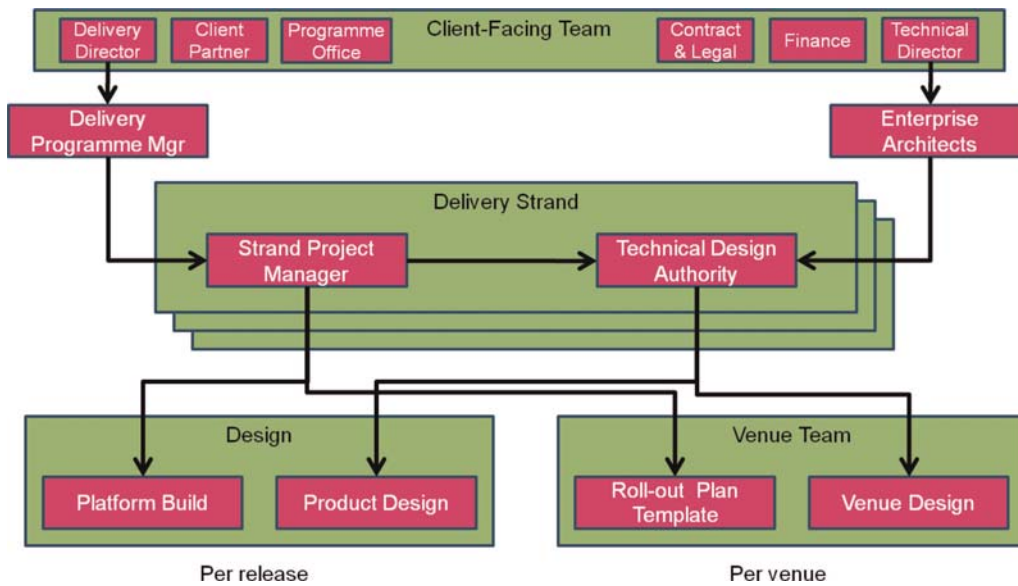


Figure 1

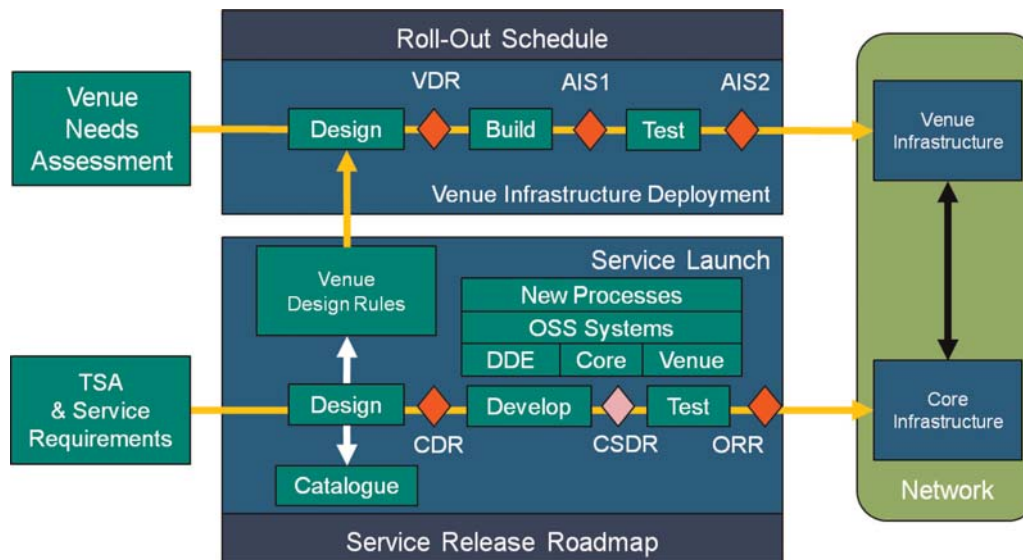


Figure 2

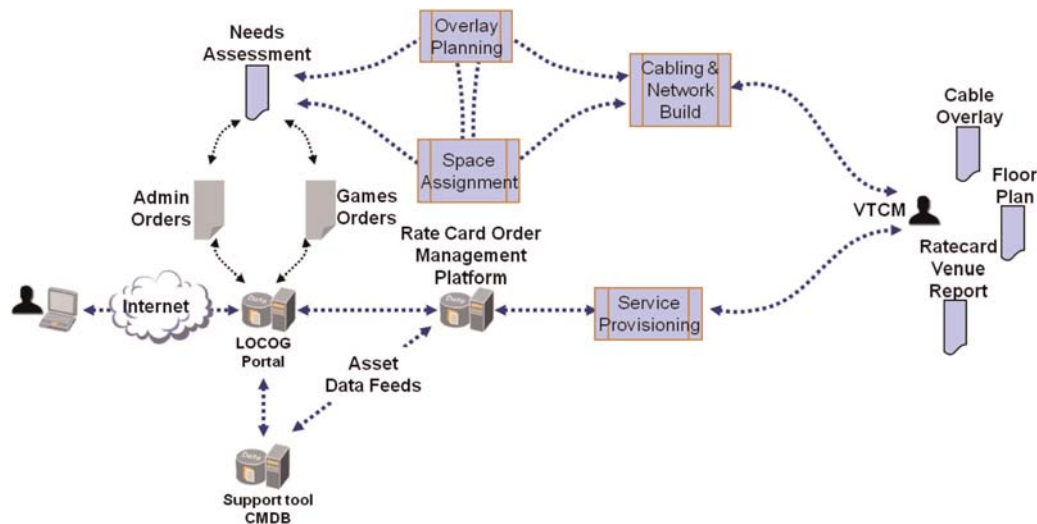
- *Security*: Assuring compliance with any countermeasures defined in the Security Policy;
- *Manageability*: Services should be backed up, restored, monitored and managed;
- *Performance and Reliability*: Capability to meet SLAs for availability;
- *Data Integrity*: Services capture the data needed for usage reporting.

However, the CDR had its limitations. The CDR occurred following detailed design, but before low-level configuration and build, hence there needed to be a subsequent review to validate that the as-built solution aligned to design and to

sign-off the differences. Furthermore, the CDR typically occurs prior to detailed process design for its service surround; hence it can review that the solution includes appropriate hooks but does not provide process assurance. Therefore there was a risk that the solution works but is not operationally ready – ‘Right Second Time’.

Hence, a second assurance step, the Critical Service Design Review (CDSR) was introduced. This mirrors the CDR approach but for processes. Again its purpose was not to test the processes (typically done by war-gaming or walk-through), but assured the coherency of the processes by the designer to present their solution through the same external views:

- *Requirements*: Providing a clear understanding of external actors, roles and systems;



**Figure 3**

- *Lifecycle*: Ensuring that coverage of the process lifecycle is achieved;
- *Security*: Ensuring compliance with any secure operating procedures;
- *Manageability*: Services should have process tracking and error handling;
- *Performance and Reliability*: Capability to meet SLAs for provisioning and service restoration;
- *Data Integrity*: Processes capture the data needed and control its change.

The outputs of both reviews and follow-up actions were then agreed through the operational readiness review, which approved the strand's service for live operation.

## 4 Venue readiness

Whilst the purpose of the strands was to build and ensure the core infrastructure, the venue teams were then responsible for ensuring that it was implemented successfully in each venue. Venue Designs were created from two sources:

- A requirement (Venue Needs Assessment) was generated from the venue Technology teams listing the services required and their locations;
- A set of venue design rules, contained in a Venue Design handbook, stated the ways in which services should be built and the prevailing naming conventions.

Using the rules, the requirements were turned into a phased design. This was subsequently authorised at a

Venue Design Review, which gave approval for any expenditure required, and allowed for optimisation of any detailed requirements, for example, the replacement of fixed services with mobile where they were being provided in an isolated location.

Implementation in a venue was governed by a structured lifecycle, illustrated above (see Fig. 3).

This presented a 28-week cycle (the Roll-Out Schedule or 'RoS'), which identified the initial design activities (taking place between weeks 28 and 22), the outputs of design and then the final 7-week deployment phase. The latter was structured to ensure that venues for which access was provided only at the last minute (such as Wimbledon) could still be delivered in time.

Equipment would be configured ('staged') off-site prior to this period and was then delivered to site to be installed along with cabling and peripherals. This not only ensured that components were burnt in, removing early lifecycle failures but also allowed for a largely 'cookie-cutter' approach to be used which deployed standard processes. Change was accommodated by supporting a couple of change windows in the process, at which point local amendments to configurations could be made, based on signed off requests. Such a change was managed centrally via a Venue Champion who owned all configurations for the venue.

Once all services had been implemented, then a Venue Readiness Review was held which signed off that all active infrastructure was installed and being monitored, and that all services had been tested and signed off by the customer. At this point, the venue was live and under full management control of the Technology Operations Centre.



# Paper 5B – Atos Programme Delivery

*Michele Hyron*

*Atos Chief Integrator for London 2012*

*E-mail: Olympic\_Games@atos.net*

With the successful delivery of Information Technology (IT) systems for five Olympic and five Paralympic Summer and Winter Games since being appointed Worldwide IT Partner by the International Olympic Committee (IOC) in 2001, Atos were in an excellent position to meet the challenge of the London 2012 Olympic and Paralympic Games. This paper provides an overview of how the programme for London 2012 was managed and an outline of some of the key activities critical to the successful delivery.

## 1 Unique contractual environment

It is firstly important to understand two unique constraints that Atos operate under when carrying out the programme management and systems integration of IT for each Olympic and Paralympic Games:

### 1.1 On-time

Unlike the majority of ICT and non-ICT programmes, even the launch of a space rocket, the Olympic and Paralympic Games cannot be delayed and they must commence, fully tested, on the agreed start date. For London 2012, some early events took place on Wednesday 25th July, several days before the opening ceremony on Friday 27th July, 2012.

### 1.2 Contractual agreements

Atos is a TOP [The Olympic Partner (TOP) Programme operated by the IOC] Sponsor, contracted by the IOC to deliver multiple Games. It is required to programme manage and systems integrate in-house developed solutions with infrastructure suppliers and other technology sponsors without having details of the contractual agreements in place between the suppliers and the organising committee. Atos has no contractual Service Level Agreements (SLAs),

service credits or contracts with any of the other technology suppliers, yet has to successfully deliver and operate the Olympic and Paralympic Games IT systems.

## 2 From Beijing to London

Following a strategy that has been subject to continuous improvement throughout these past Games, the starting point for the Atos team in London was the Technology debrief of the Beijing 2008 Games. This was the time in November 2008 when many key members of the Atos team relocated from China to the UK and, along with the Beijing Organising Committee (BOCOG) and other technology partners, formally presented their review and lessons learned to the London Organising Committee (LOCOG), the IOC, IPC and other stakeholders.

With the incredible pace of activity leading up to and during the Games, the preparation and delivery of the debrief is an essential part of the Olympic and Paralympic lifecycle. It provides the team with an opportunity to step back and identify best practices to be repeated and to agree what they would do differently next time around. For London, a range of enhancements and lessons learned were captured, of which the following are just a few examples:

- The need for an early architecture design to enable Core Games System (CGS) workforce applications to go into production in advance of the final, more complex strategic architecture being ready;
- The growing profile of the Paralympic Games and the corresponding increase in expectations for IT;
- Factor in more time for planning of disaster recovery activities to minimise prioritisation issues with technical rehearsals.

### 3 IT Master Plan

Fresh from the debrief, one of the first tasks undertaken by the Atos team was the development of a plan encompassing the programme management, integration, development and operation of the Info Diffusion Systems and Core Games Systems that Atos would subsequently deliver for London. This plan, referred to as the IT Master Plan, was purposefully kept to a high-level despite the complexity and large number of interdependencies associated with delivering the Games. Key tasks and milestones were identified instead of trying to include very granular levels of detail, which was a 'lesson learned' dating back to the Salt Lake 2002 Olympic Winter Games. This approach ensured that the plan always remained a useful and manageable tool without requiring significant levels of resource to maintain and update it – resources that were better focused on actual delivery. Naturally, the plan was 'front loaded' with tasks to define how to manage aspects of the programme such as quality, configuration, change, risk and so on. The dates of the Olympic and Paralympic Games also featured, but as they were of course immovable, there was no point in recording any dependencies for them.

The IT Master Plan was subjected to periodic reviews and updates throughout the lifecycle of the programme, however from inception it was subject to strict change control to achieve discipline on hitting deadlines. Along with regular risk assessments and identification of risk mitigation activities, the IT Master Plan represented a key tool for the Atos management team.

Following on from production of the IT Master Plan, another important task undertaken early in the programme was to carry out a detailed review of roles and responsibilities across the various partners involved in delivering the Games. This review included LOCOG, the IOC and other Technology sponsors, however without all domestic sponsors on-board at this stage it also served to help scope what those sponsors would subsequently be asked to sign-up to. The results of these discussions were captured in a simple matrix format, although it is interesting to note that this required little reference throughout the remainder of the programme: the real value was in bringing together all parties to debate and agree what each would do, thus identifying gaps or overlaps at the outset and avoiding issues later.

### 4 Gap analysis

The CGS applications deployed by Atos for the Vancouver 2010 Winter Games provided a baseline at the start of the London programme. These applications are essentially the same from summer to winter events, and the Vancouver versions were used for a gap analysis that Atos carried out in conjunction with LOCOG business owners in order to agree developments necessary for London. Whilst this gap analysis took place in 2009 before the Vancouver Games,

the applications were still sufficiently mature because they were operational long before to support volunteer registration, accreditation and other functions that must prepare early.

### 5 The Red Books

The Atos Games IT Systems are always a close integration of hardware, software and services provided by a range of other TOP and LOCOG domestic sponsors and suppliers and as such, there has to be clarity in exactly what each party is required to deliver. Therefore Atos needed to determine the systems and network architecture and accompanying operational support plans, allowing sufficient time for existing sponsors to prepare and giving LOCOG the opportunity to bring in new sponsors or suppliers where necessary.

This was a challenging exercise. Whilst collateral and knowledge from the preceding Beijing Games was used to inform the baselines for architecture and operations for the London Games, many new factors had to be taken into account when determining the approach.

The Atos development team in Barcelona was working on a new version of Info Diffusion for introduction in London, enhancing delivery of real-time results for the system that provides results and other information to media and broadcasters across the world. But beyond this it was necessary to consider:

- Changes in scope identified during the gap analysis;
- The continuing evolution of technology;
- Changing client expectations;
- The involvement of new sponsors, bringing new products and services;
- Unique aspects of the London Games, such as accounting for the number of competition and non-competition venues and their distribution in the Olympic Park and elsewhere across the country;
- The growing challenges of cyber security.

In parallel with defining the new architectural and operational blueprints for the Games IT Systems, Atos also captured their requirements for hardware, software and support resources to be met by LOCOG and the pool of sponsors and suppliers. These requirements were documented in what was commonly referred to as the Red Books (simply on the basis of the colour of the folder once used to hold them) and they were used by LOCOG as the basis for detailed budgeting and procurement activities, as well as by existing sponsors to set the baseline requirements for their deliveries. The scope of these Red Books included:

- Acer desktop, laptop and server hardware,
- Operating systems software,
- Storage and backup,
- Software platforms,
- Cisco network equipment,
- Reprographics equipment,
- A range of security and monitoring software and tools,
- Specialist support arrangements for the above.

## 6 Testing

During the course of the London 2012 programme, Atos carried out in excess of 200,000 hours of testing in a purpose-built 2000 m<sup>2</sup> Integration Test Lab (ITL). Using the components and services defined within the Red Books to build an architecture mirroring that of the final production infrastructure, Atos carried out repeated functional and non-functional testing of each new delivery to ensure it would be fit for purpose. However, not all testing took place within the ITL and systems were required to meet the 'real-world' during the 42 test events, which commenced with the Marathon in May 2011 and ended almost exactly a year later with Paralympic Athletics. Atos deployed the sport-specific On-Venue Results systems and associated infrastructure from the ITL to the venues for these test events, complete with network connectivity to the data centre for end-to-end testing. In order to maximise the benefit available from the test events, the

configurations on venue matched as closely as possible what would ultimately be used during the Games. Following each event the equipment was relocated back to the ITL for lab-based testing to continue (see Fig. 1).

Clearly for Atos, LOCOG and other partners the test events represented a considerable logistical and operational exercise and required close co-operation, serving not just to prove systems and applications but also helping to embed processes and ways of working across the teams.

In addition to the test events, the two technical rehearsals were another critical activity within the overall IT Master Plan and these were focused on ensuring operational readiness for the Games. They were carried out in March and May of 2012 and are detailed more fully in the Atos paper on Technology Operations.

## 7 Deployment

The rapid deployment of IT in the rush to any Games always represents a significant delivery challenge. With so much to do and so many other suppliers and contractors fitting out venues with furniture, power, lighting etc., then it is typical that the IT installation teams are juggling their activities to make the best use of the time available on venue.

London 2012 was no exception, and the Atos approach of minimising the on-venue installation work through standardisation and simplification was once again a key success factor. The architecture defined a limited number of hardware, software and configuration combinations that could be used and each of these was allocated a unique 'finished product' code. Each finished product was tested through the ITL and test events and an accompanying set



**Figure 1** Integration Test Lab

of quality assurance (QA) checklists developed as a means of verifying correct installation at venue.

Atos were also responsible for the set up and operation of the Equipment Distribution Centre (EDC) where the many thousands of PCs, printers, network components and other systems were prepared and configured for use at the venues. Operational from March 2011 in time for the first test event, the primary function of the EDC was to consistently turn out the required quantities of each finished product ready for installation. However, providing the EDC with an instruction to build the finished products was the culmination of a considerable amount of planning activity, taking place over a number of years and involving repeated consultation with representatives from other business areas across LOCOG and with external stakeholders. This activity required a strong partnership between the LOCOG Venue Technology Manager and the Atos Venue IT Manager, who were ultimately responsible for the installation and operation of all Technology at their allocated venue.

## 8 Conclusion

This paper has provided a brief summary of a number of key activities undertaken by Atos to achieve successful delivery of the Games IT Systems for the London 2012 Olympic and Paralympic Games; however it is also important to highlight the operational aspects of the delivery which are covered separately in the Atos paper on Technology Operations.

In conclusion and returning to the IT Master Plan, the final tasks for the Atos team for London 2012 have now been completed. Over the course of a week in November 2012, members of the teams from LOCOG, Atos and other Technology partners formally presented their review and lessons learned to the Rio Organising Committee, the IOC and the IPC. Members of the London Atos team have now relocated to Rio and commenced the cycle again for the Summer Olympic and Paralympic Games in 2016, with others deploying to Sochi, Russia to deliver the Winter Olympic and Paralympic Games in 2014.



# Paper 6 – Operating the technology at the Games: an overview

*Gerry Pennell OBE*

Chief Information Officer, LOCOG  
E-mail: gerry pennell@gmail.com

The scale of the deployment and operation of the wide range of technologies and suppliers required for staging an Olympic and Paralympic Games to the demanding service level is exceptionally challenging from an overall management and governance perspective. For London 2012, a combination of approaches was adopted and integrated through some central operational governance and oversight mechanisms.

## 1 Introduction

This paper provides an overview of the management approaches adopted to deploy and operate the technology required to stage the London 2012 Olympic and Paralympic Games.

It excludes the project delivery of the various technologies involved, a related challenge, which is the topic of a separate paper [Paper 5 Managing the Delivery of the Games Information and Communication Technologies (ICT): an overview].

## 2 Scope

The focus of this paper is on the deployment and operations of the set of systems and technologies that were required by the Organising Committee to operate the Games themselves, to measure and record the sporting performance(s) and to distribute that data to the many different audiences that consumed it.

In outline, LOCOG working with its partners and suppliers implemented all the following:

- A set of applications to assist the management of the Games: for example, Arrivals and Departures, Medical

Encounters, a Rate Card portal and issues tracking and management system.

- A set of on-venue results applications from Omega and their sub-contractors integrated with the relevant timing and scoring devices on venue and with a central information distribution system developed by Atos.
- A Commentator Information System, new for London, developed by Atos alongside a browser-based information system (myInfo+) primarily targeted at the written media and available on their own devices (new for London).
- A set of data-feeds to enable broadcasters, press agencies and others to use the results information delivered using the new Olympic Data Format (ODF) and to update their own web-sites and applications.
- The organising committee's own web-site, content distribution system and associated mobile applications on four platforms. The first games where real-time results were available across these channels for all sports.
- Scoreboards, video-boards and other audio-visual technologies on venue not least to support LOCOG's drive to enhance the presentation of sports for spectators.
- A converged IP network delivered by BT to support voice and data between all the competition and non-competition venues used in the Games.
- A dedicated trunked digital radio network provided by Airwave plus some specific radio technologies to support local requirements, not least for some of the road events.

Excluded from the organising committee's direct responsibilities was IT used by providers of operational or marketing services as part of their own operations; for example, the ticketing systems and web-site implemented by Ticketmaster.

### 3 Overall philosophy and management approach

The operational deployment and delivery was geographically split between central and venue locations.

The central facilities were the Primary Data Centre (PDC) and the LOCOG Technology Operations Centre (TOC) and contingency facilities for a Secondary Data Centre (SDC) and Alternative TOC. The latter facility being co-located with a location for the backup Main Operations Centre (MOC), which was the overall command and control centre for the Olympic and Paralympic Games.

Each competition and non-competition venue also had a devolved technology operation, responsible for local deployment ('bump-in'), support and decommissioning ('bump-out'). As far as possible, each venue could operate stand-alone and, in the event of a catastrophic network outage, continuance of the event would not have been threatened although distribution of results and video feeds might well have been.

In both central and distributed locations, LOCOG opted to retain operational management control and not attempt to out-source this responsibility to one of the providers.

Although the majority of technical delivery was out-sourced to sponsors and suppliers, technology management was clear that responsibility and decision making needed to be retained by the organising committee and so, unlike some previous Games, a venue technology manager (VTM) employed by LOCOG was appointed for each venue. The wisdom of this decision was proven by the number of late scope changes and additions, which the VTM was able to manage without the constraints and complexities that an out-sourced model would undoubtedly have introduced.

The Technology Operations Centre had representation from all of LOCOG's key suppliers but management responsibility was retained by LOCOG with the TOC Director role always staffed by a member of LOCOG technology's leadership team.

### 4 Key challenges and the organising committee's response

The operation of the technology at a major multi-sport event such as the Olympic Games brings with it a number of challenges that are slightly different from the conventional ICT operation.

#### 4.1 Building an integrated operation

The suppliers to the organising committee were diverse with a wide range of approaches to operations, as well as being culturally diverse with UK, European and Far East companies being actively engaged. A major challenge was to develop a model that was implementable by all organisations but sufficiently integrated to give LOCOG adequate management oversight.

All the key providers were engaged in the development of a Service Management Architecture, which was produced by the summer of 2011 (and incrementally enhanced thereafter). This became the essential vehicle for discussing and agreeing to the operational approach.

#### 4.2 Building operational maturity

In most organisations, operational maturity develops over time and changes are made incrementally to an existing operation. Of course, the Olympic and Paralympic operations were live for a small number of weeks only and so not really an opportunity to build operational processes and experience. However, the demands of key clients, notably broadcasters and press agencies, are very high and there was a need to embed good operational practice prior to the Games beginning.

As well as Test Events (refer to the section Managing the delivery of the Games ICT: an overview), two key operational testing and proving exercises were run in March and May 2012. Known as 'Technical Rehearsals' the objective of these exercises was to test the operation under pressure. Each exercise was a week long and employed external technical rehearsal officials to implement scenarios and also monitor the performance of the operation and feedback. Competition was simulated in the venues and a variety of scenarios, ranging from minor technical failure to major cyber-attack of central facilities were exercised. Many of these scenarios were physical, that is, not simply paper exercises.

#### 4.3 Service levels

Service levels for Olympic and Paralympic Games are of course very demanding. A conventional corporate help desk model would be unlikely to deliver the responsiveness required.

The philosophy developed relied on:

- significant local support (and provision of spares) in all the critical venues with service desks in each venue;
- the use of volunteers alongside LOCOG and supplier staff to provider front-line ('level 1') support;
- a central call centre whose mission was to route incidents for action rather than to attempt to resolve calls immediately.

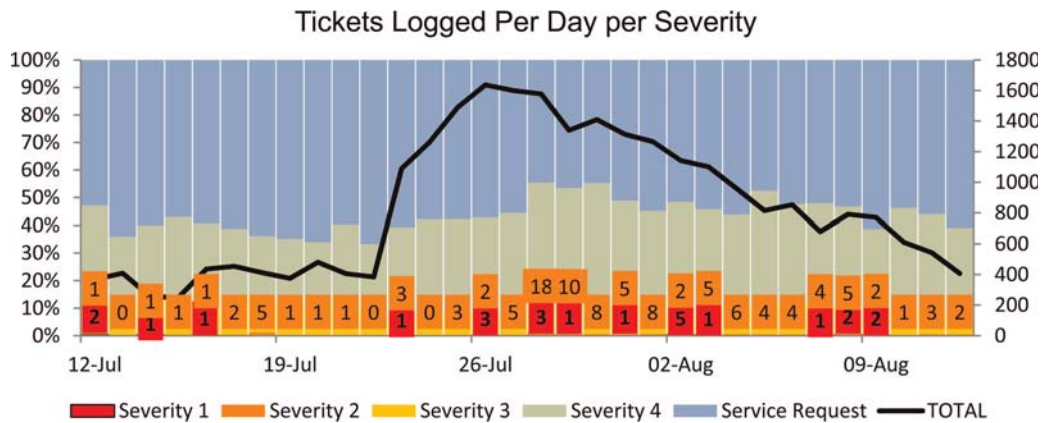


Figure 1

Alongside the local support model, the TOC monitored overall performance and trends and was also the location for deep technical expertise and/or liaison for all the key suppliers. During the Olympic Games the TOC operated on a 24 × 7 basis working on a 12-hour, three-shift pattern, see Fig 1.

#### 4.4 Sports statistics

One of the tasks of the organising committee was to collect and collate relevant statistics from various sports which are relevant to the reporting of the event, for example, player fouls at field hockey. Volunteers with sports expertise and keyboard skills were trained and deployed near the field of play to collect this information, which was distributed via the results network.

#### 4.5 Print distribution

As with all multi-sport events, the distribution of paper start-lists, official results and related documentation in line with the requirements of key groups (technical officials, Olympic Family, journalists etc.) is a major logistical challenge. This

was another operation largely staffed by volunteers under the management of LOCOG.

#### 4.6 Cyber security

Prior to the Games, there was much speculation in the press – and elsewhere – as to the risk of external cyber-attack disrupting the Games. The Cyber Security Resilience paper describes the technical response in more detail [Paper 3] – however, the operational response was as important and consisted of a 24 × 7 security operation based in the TOC with communication channels to the relevant government agencies and key suppliers, notably BT and Akamai (sub-contracted via BT).

The Games were subjected to a number of attacks from ‘hactivist’ and other groups and the sophistication of the attacks ranged from the fairly amateur to high volume and automated. Fortunately, the architecture implemented was unaffected and there was no impact on operations or information delivery.



# Paper 6A – BT approach, technology operations

*Andrew Parker*

Head of Service, BT London 2012 Programme  
E-mail: [andrew.s.parker@bt.com](mailto:andrew.s.parker@bt.com)

As the communications provider for the London 2012 Olympic and Paralympic Games, BT was a critical component in the overall technology operations model. The challenge from the outset was for BT to draw on the strength and depth of our organisation parallel to providing the flexibility and agility required to deliver the network and other services supporting the Games.

A tiered approach to operational support was developed providing multi-skilled support teams at each venue, highly skilled experts in the Technology Operations Centre (TOC) covering all technologies, services and product groups within a single operational function all backed up with the depth of expertise across BT's well-established operations centres across the UK and around the globe. The overall model is illustrated in Fig. 1.

This operating model provided BT with the ability to respond immediately and appropriately at the venue level, to provide central command and control across complex technology challenges with the TOC and to use the strength of the wider organisation in delivering a flawless operation of the 2012 communications services.

The service operation was founded on the principles of the Information Technology Infrastructure Library (ITIL) framework, albeit it was used as a reference framework rather than an entire blueprint. This enabled the team to reference best practices in a targeted way, and to adapt them to meet the needs of the unique nature of the Olympic environment. Key areas of focus that underpinned the success of the operational management of the Games communications infrastructure were:

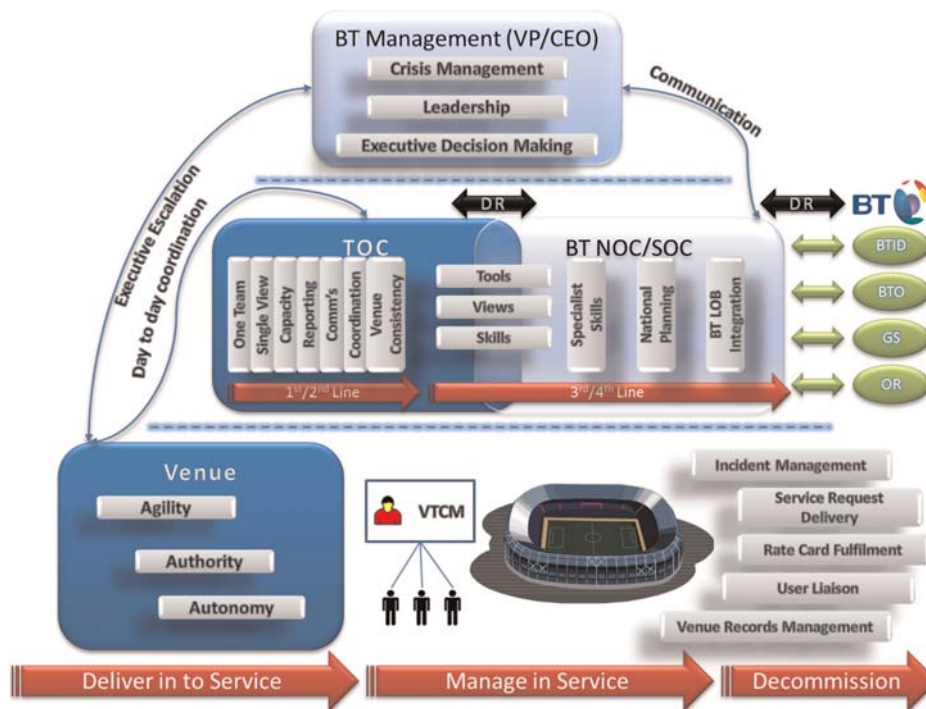
*Industrialised service transition:* Ensuring that all services were consistently built and tested against a standardised

framework and introduced to live service through a rigorous assurance process. This was balanced against the need to operate flexibly, by delivering components of services early in some cases in order to cater to the needs of early arrivers/adopters within the Olympic Family.

*Uncompromising change management and service protection:* Any changes that were deemed critical to the operation of the services were subject to microscopic technical and service assessment prior to approval to implement. Even reactive activity was controlled during competition with a list of activities which were precluded during competition or in the 2 hours before competition, for example, staff were not allowed into the Telecom Equipment Room during competition hours unless there was a major service-affecting incident and formal approval was given by the LOCOG TOC. This was underpinned by an enhanced BT Group wide 'service protection' policy ensuring the operational integrity of the entire BT national service infrastructure.

*Integrated system monitoring:* Bringing together tens of thousands of monitoring parameters across the entire spectrum of technology, infrastructure and service components into a single service health view within the TOC. A comprehensive end-to-end horizon view of the entire network was enabled supporting a true mission control capability. The use of BT's existing and proven operational tools was the fundamental building block to this success, albeit the integration into a single capability was the operational differentiator in this critical and highly visible environment.

*Methodical incident management:* While designing out risk, and leaving 'no stone unturned' was a fundamental ethos within the programme, we recognised that there are always



**Figure 1**

factors that arise that can result in unplanned interruptions to service, no matter how large or small. BT adopted a tiered approach to incident management enabling low-level incidents to be handled routinely by the venue and first-line support teams, leaving highly experienced incident managers and technical staff to deal swiftly, methodically and effectively with high-impact major incidents. The major incident managers worked to a methodical approach in dealing with issues and maintained consistency across the team regardless of the individuals working on shift at any one time. This contributed significantly to BT delivering a flawless operation.

*Integrated resourcing approach:* Processes and tools are critical in ensuring consistency in approach and tight control; however, without the right people it is impossible

to capitalise on this. BT's approach to resourcing for the operational delivery of the Games was arguably the key differentiator in this programme. Bringing together a team of ~800 carefully selected individuals from across all its many lines of business into a single integrated team to manage the 2012 communications services was a true success. Never before has this level of integration been seen across the entirety of the BT business; however, the success has been plain to see. With only 1% of its overall workforce dedicated to the Games, BT has delivered a truly 'flawless Games'.

Furthermore, the people who worked on the Games are now being redeployed throughout BT's business. They are taking with them new processes and improved ways of working – providing a further legacy for BT.



# Paper 6B – Atos Information Technology Operations

*Pieter-Jon Buitelaar*

*Atos Operations Manager for London 2012*  
*E-mail: Olympic\_Games@atos.net*

Atos was in a unique position for the London 2012 Olympic and Paralympic Games. This was the first time the Games had come to a country where Atos had a large national presence. In the UK, Atos provides programme management, systems integration and operational support to Central Government, financial institutions, manufacturing, transportation and enterprise customers. A number of these businesses/departments had significant roles to play supporting the Games, and Atos were required to continue delivering uninterrupted or even enhanced levels of service to them whilst simultaneously meeting the challenge of delivering Games Information technology (IT) Services. These organisations included:

- London Organising Committee for the Olympic Games and Paralympic Games (LOCOG)
- Olympic Delivery Authority (ODA)
- Department for Culture, Media and Sport (DCMS)
- UK Border Agency/UK Border Force (Home Office)
- Network Rail
- Association of Train Operating Companies (ATOC)
- Department for Transport (Olympic Journey Planner)
- Brakes Foods
- BBC

## 1 LOCOG operations

LOCOG was tasked with the preparation and staging of the London 2012 Games. From a technology perspective,

London 2012 represented the largest and most sophisticated sports IT project of all time. The Atos delivery of Games IT Systems supported LOCOG, the International Olympic Committee (IOC) and the International Paralympic Committee (IPC) in meeting the challenge.

Delivery of the Atos Games IT Systems required four years of programme management, integration and development, yet success was focused on the outcome of approximately 30 days of Olympic and Paralympic competition in the summer of 2012, when even the smallest glitch had the potential to be a news headline.

The shift to an operational mode occurred gradually through the lifecycle of the London 2012 programme, with some systems going live up to two years before the opening ceremony. This paper outlines how Atos managed the delivery of Games IT Operations during the years of preparation leading up to London 2012 and ensured that an effective and cohesive operations organisation was in place ready for when the Games opened.

## 2 Volunteer registration

Volunteering was introduced to the modern Olympic Games in 1948 when London hosted the Games of the XIV Olympiad, and since then the volunteers (Games Makers) have become an intrinsic part of the operational success of the Olympic and Paralympic Games.

Atos provided the London 2012 Volunteer portal in the summer of 2010, enabling people from across the world to apply to become a Games Maker. By the end of October 2010, the portal had enabled more than 240,000 people to apply for the 70,000 Games Maker roles necessary to deliver the London 2012 Olympic and Paralympic Games.

This paperless system allowed individuals to register via the internet and, for the majority, it represented their first direct interaction with the organisation. It was therefore essential for Atos and LOCOG that volunteer registration was a success and established credibility at the outset.

Such early deliveries in the programme were a challenge, needing to take place in advance of the strategic Games-time architecture being ready and before the LOCOG data centres were available for fit-out. They also represented a potential distraction from preparations for the Olympics and Paralympics in 2012 and it was important to ensure that the team remained focused on the final goal. To contain this situation, the shared services available from Atos UK data centres were used, initially for volunteer registration but ultimately for the full range of Atos workforce systems including management of communications between LOCOG and Games Makers. With the infrastructure managed by the data centre operations team, the Atos Games IT resources were able to limit their involvement to applications support and therefore continue planning towards 2012. In addition, this approach enabled the volunteer system to benefit from a cost-effective 'lights-out' disaster recovery environment hosted in a Tier 4 data centre, which would otherwise not have been possible at this stage in the programme.

### 3 IT service management

The second early deliverable for the Atos team during 2010 was the establishment of the IT Service Management system to meet the change and incident management requirements of Atos, LOCOG and the other technology partners through until the end of the Paralympics. Leveraging advances in technology and taking a new approach for the Games, Atos selected and then customised a cloud-based Software as a Service (SaaS) IT Service Management tool. Built on the IT Infrastructure Library, the service provided capacity to meet the needs of

the growing organisation whilst helping to minimise the infrastructure footprint.

The Atos team delivered user training to all technology partners to embed the disciplines of using the IT Service Management system and to achieve their objective of making it the single source of information for all changes and incidents. Crucially, this training included standardised definitions and service levels for incidents, as these had to be used consistently by the entire team in order to be fully effective. Each incident was allocated a severity, ranging from 1 to 4 (1 being the most severe) and the definition, response and fix time depended upon whether it had occurred during a critical or non-critical period. The test event competition schedule, technical rehearsals and the Olympic and Paralympic Games operations phase dictated the critical periods and during these times the incident severity definitions also accounted for any impact to the running of events. Table 1 shows the definitions applied to severity 1 and 2 incidents during critical periods, along with the required response and fix times.

### 4 Technology Operations Centre (TOC)

Atos and LOCOG worked in close partnership to establish the TOC to support the Olympic and Paralympic Games. Based in the LOCOG offices in Canary Wharf, at any one time during the Olympic Games the TOC was home to nearly 200 staff representing Atos, LOCOG and the other Technology partners. However, in mid-July 2012 with the move to 24-hour operations, total staffing across all of these organisations was closer to 600 people in order to meet the demands of shift working (see Fig. 1).

Classified as a non-competition venue and following the same approach used for all venues, the TOC was planned and ready for the first test event, the Marathon, which took place in May 2011. With a slightly smaller footprint than

**Table 1** Severity 1 and 2 incident definitions, response and fix times for critical periods

Incident severity and definition	Response/fix time
Severity 1: A critical system/service is not operational or there is a safety or life-threatening situation <ul style="list-style-type: none"> <li>• The competition/event is severely impacted</li> <li>• All users of a service are affected</li> <li>• There is a threat to safety or</li> <li>• The problem/failure is highly visible and known to the media</li> </ul>	5 min/1 hour
Severity 2: A critical system/service is at risk but not currently impacted or a problem exists but it is not critical <ul style="list-style-type: none"> <li>• The competition/event is at risk but not currently impacted</li> <li>• A high proportion of users of a service are affected and cannot perform their required tasks/duties, however a small number of users of that service are not impacted</li> <li>• Loss of resilience</li> <li>• There is a potential threat to safety or</li> <li>• The problem/failure is potentially visible to media</li> </ul>	5 min/2 hours



**Figure 1** *Technology Operations Centre (Test Event Configuration)*

the final Games-time TOC configuration, the TOC was staffed throughout each of the 42 test events and typically for several days either side of each event to support venue 'bump-in' and 'bump-out' [Common terminology used within the Olympic and Paralympic Games for the venue installation and decommissioning activities that take place immediately before and after events] activities. Prior to this however, Atos were delivering Technology Call Centre services from early 2008, with level 1 analysts logging and assigning incidents in an arrangement that finally peaked to a Games-time requirement of up to 30 staff per shift.

The design of the TOC was optimised to serve the needs of senior managers and specialists from all areas of technology. The layout was carefully planned to place teams according to who they most frequently communicated with and screens dedicated to the Atos IT Service Management system were mounted at high-level: as soon as a severity 1 or 2 incident was logged it automatically appeared on these screens for immediate attention.

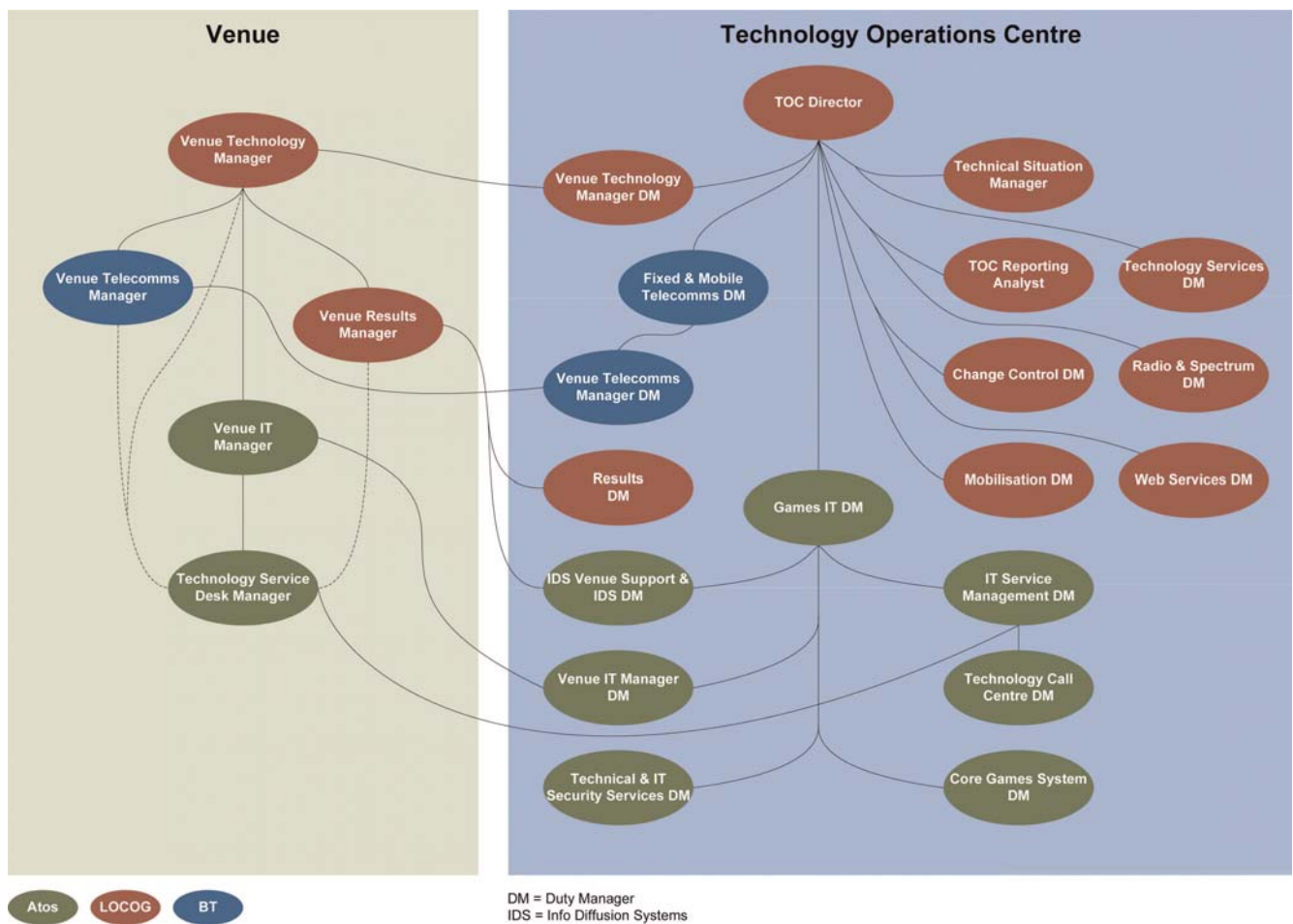
The TOC was a highly structured command and control organisation with clear lines of responsibility and reporting, and every individual had a set of documented processes and procedures appropriate to their role. In what can be a highly pressured environment, this approach minimised the opportunities for time-wasting confusion when dealing with a high-severity incident. Over the years of delivering the Games IT Systems, Atos have developed a library of processes and procedures and these were updated to reflect the specific environment and the new and updated solutions implemented for the London Olympic and Paralympic Games. Many of these processes and procedures were highly technical and specific to individual teams who had to take responsibility for defining, refining, learning and

communicating them, whereas a centralised approach was taken for others that were more generic in nature. For example, the Atos Crisis Communications Management Procedure defined how to handle a severity 1 incident that required explanation or communication to stakeholders in the media or public domains [Not all severity 1 incidents were classified as a crisis; this was a TOC management decision]. This procedure was refined and updated through the test events and formal training sessions were provided to the teams from Atos, LOCOG and other technology partners. This training included table top exercises with all relevant individuals working through potential scenarios to really understand the procedure and how it should be used.

The Atos Red Books were described in the separate paper on Atos Programme Management and these defined the hardware, software and support resources required from LOCOG and other sponsors and suppliers in order to build the Games IT Systems and associated support services. Specifically, the documentation on support resource requirements included a concept known as escalation support, which was the availability of the most senior fourth-line technical specialists to cover critical hardware or software components. With such a high-profile critical infrastructure and a very short operating window, this approach saved valuable time by allowing standard vendor call-logging processes to be bypassed in favour of directly interfacing to technical experts, either locally or remotely.

## **5 Venue organisation**

Whilst the TOC was a highly centralised model, the competition and major non-competition venues included a significant on-site support presence. Within each venue team, the Atos Venue IT Manager was responsible for the



**Figure 2** High-severity incident communications

planning, deployment and operation of IT systems and this included the provision of a local service desk. Comprising of Games Makers as well as technicians drawn from sponsors and suppliers, the venue service desks operated by Atos were led by a Technology Service Desk Manager and their primary objective was to log all incidents and, as far as possible, resolve them at a local level.

By ensuring that all incidents were diligently recorded in the IT Service Management system, the TOC was able to maintain oversight across all venues and serve as the route for management or technical escalation. To further ensure that high severity incidents (i.e. those at severity 1 or 2) received an immediate response, a supplementary procedure was also used for notification across the technology organisation, as shown in Fig. 2.

## 6 Test events and technical rehearsals

The London Prepares Series test events were actual sports competitions that exercised all aspects of delivering the Games, not just technology, and they included national and international competitions such as the FISA World Rowing Junior Championships, the UCI BMX Supercross World

Cup 2011 and the Olympic and Paralympic swimming trials for Team GB. Test events have always proven invaluable throughout the 20 years that Atos have been involved in major sporting events, and the London Prepares Series was no exception in bringing together the many different partners, building the team and embedding processes and procedures.

Whereas the aim of test events was to successfully implement and operate Games IT Systems for competitive events, the purpose of the two technical rehearsals was to stress the operational capabilities of the venue teams and the TOC and highlight any deficiencies in the organisation, processes and procedures. Taking place over a one week period in March 2012 and then again two months later in May, a wide range of failure scenarios were devised in advance by Atos, LOCOG and the Technology partners to put their teams to the test. These scenarios covered all manner of technical, staffing, logistics and crisis situation.

The three busiest days of competition were simulated during the Technical Rehearsals, with Technical Rehearsal Officials touring the venues and the TOC to inject the scenarios, observe and record responses and subsequently provide feedback. This was arguably one of the most challenging periods for the TOC in particular, which had to deal with the

convergence of severity 1 and 2 incidents arriving from venues, however it was an essential part of preparing for the Games as it instilled the discipline of following defined lines of communication and using correct process even under pressure.

## 7 100 days to go

The final 100 days leading up to the opening ceremony on 27<sup>th</sup> July were a rush of activity, and in this time:

- The Atos team more than doubled in size from 150 to over 330 individuals.
- The final technical rehearsal for the Games IT Systems was carried out. In total over the course of the programme, the LOCOG and Atos teams executed more than 200,000 hours of testing in the Integration Test Lab, simulating more than 9000 test cases across the full range of Olympic and Paralympic sports.
- Atos supported the qualification process for more than 14,700 athletes competing in London 2012.

- Accreditation of over 280,000 individuals attending the London Games concluded.

- Fit-out of the media and broadcast centre with Games IT Systems completed and the Atos Info Diffusion Systems were brought online ready to deliver real-time results to the world's news press agencies and broadcasters.

## 8 Conclusion

By the time of the opening ceremony for the London 2012 Olympic Games, a disciplined, well-trained and experienced IT organisation was in place, comprised of individuals from Atos, LOCOG and other Technology partners as well as Games Makers with their infectious enthusiasm. During the key operational period of 12<sup>th</sup> July to 12<sup>th</sup> August 2012, this team managed nearly 27,000 incidents including nearly 140 severity 1 and 2 incidents, without impact to competition, contributing to a hugely successful London 2012 Olympic and Paralympic Games.



# Paper 7 – Supporting third-party equipment overview

*David Finch*

Senior Manager, Architecture & Security, LOCOG  
<http://uk.linkedin.com/pub/david-finch/2/a21/361/>

Looking back at major events of just a few years ago, the landscape was very different in terms of using personal computing devices and Games IT systems. Mirroring the challenge that major corporations have been facing with Bring Your Own Device (BYOD) strategies, past Games did not cater well to journalists, athletes and others wishing to use their own device to access information available on the closed environments used to provide secure, highly available Games IT systems: rather than using their own laptop, for example, a journalist would previously use one of a group of dedicated kiosk machines shared with all the other journalists, potentially printing out a news item or results sheet and then retyping it for their own news story.

A different approach was necessary for London 2012, reflecting the modern way of working and providing an integrated set of services to support these user groups needing to quickly and accurately receive and process all manner of Games information. Members of the press have probably the most comprehensive needs, given their tight

deadlines for submitting news stories they need information available with a minimum of fuss, and for these users the following services were made available (see Table 1).

In addition to these services supporting users as individuals, the need to support corporate IT systems was also catered for. BT provided Direct Internet Access services that allowed organisations to set up their own systems for access from the internet, for example, Email and Web Servers; Atos provided the Olympic Data Feed to deliver results and other Games-related information in an XML-format for bespoke processing by the recipient organisation (for the first time this was also made available over the internet).

The following papers provide further detail on the solutions constructed by BT and Atos to deliver the integrated set of services that enabled the media and others to use their own IT systems during the Olympic and Paralympic Games.

**Table 1**

Identity Management	A common self-service solution provided by Atos to enable users to have a single username and password combination across the services
Rate Card Internet	Provision of high-quality wired and wireless internet access at venues, delivered by BT
myInfo+	Online access to the Atos system providing a full range of Games information, including results, news stories, athlete biographies and more. Much of the content was available in downloadable Portable Document Format (PDF) files
myPrint	A hosted print capability supporting a defined set of formats, most notably PDF for use with the myInfo+ content, but also MS Word and others



# Paper 7A – BT supporting third-party equipment

*Tim Boden*

Technology Director, BT London 2012 Programme, BT  
E-mail: [tim.boden@bt.com](mailto:tim.boden@bt.com)

## 1 Supporting third-party equipment

A wide variety of accredited organisations attended the Games, ranging from press reporters and broadcasters to national sporting organisations and international federations. All brought their own equipment to the Games, ranging from stand-alone PCs to turnkey networks supporting hundreds of users, and all shared a common need to have connectivity from within Olympic venues to the outside world.

To provide some indication of scale, over 5600 individual accounts for accessing the internet were sold during the Games, together with over 400 dedicated internet connections, the latter supporting an aggregate bandwidth of just under 10 Gb/s. On top of this, many of the sporting organisations were provided with an allocation of 'free issue' connectivity as part of LOCOG's contract with the International Olympic Committee (IOC).

As a result, configuring, managing and operating these services effectively were critical during the Games, with much of the Games' press and photographic output being carried across them.

## 2 Rate card Internet access

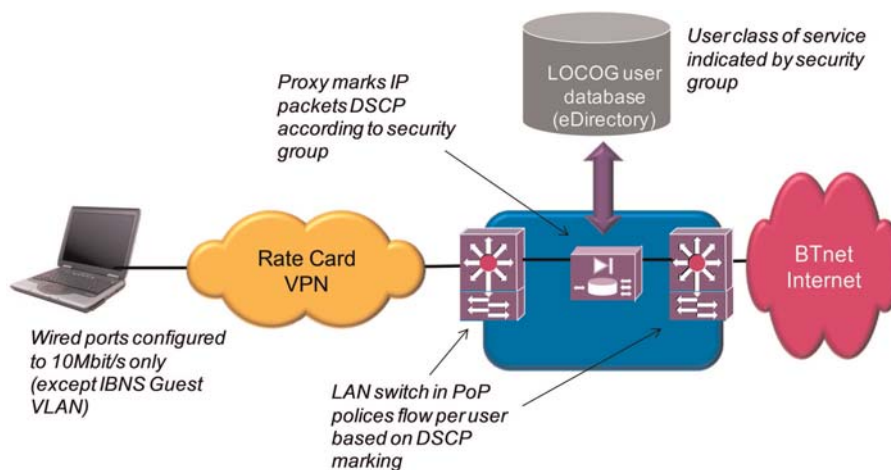
Rate Card Internet Access was designed to allow easy, secure access to internet websites, email, VPN and other common applications from user-owned PCs, Apple computers and mobile devices. User PCs location varied, in private offices or press tribunes, with dedicated LAN connections, or in common areas with shared LAN sockets. A limited

wireless service was also available in lounges and conference rooms.

Two grades of service were available for purchase: Basic (1 Mbps) and Standard (8 Mbps), both using a nominal 1:20 contention ratio. These throughputs were bidirectional – both to and from the internet. Internet access allowed access to any internet-accessible Olympic services, such as the myInfo+ portal, and to LOCOG provided shared printers in the venues.

Both wired and wireless connections provided filtered access to the internet – via firewalls, proxy servers and virus scanning in the core infrastructure. This protected the users from common internet threats such as viruses and worms to supplement the protection installed on the users PC. The proxies also provided limited universal resource locator filtering and application level firewalling and increased performance by caching frequently used web pages.

Access to the service was via a separate internet access LAN port, nearly 20,000 of which were provided across the Olympic venues. The user logged onto the service with a web browser, in a similar fashion to a wireless hotspot or hotel internet system. Each user was provided with a username and password, which was validated against a directory service and the appropriate grade of service selected. Only one device could utilise the username at the same time, subsequent logons caused the older connection to be dropped. This username was required as the service was chargeable; however, it was also the cause of many service issues, particularly where individuals forgot their usernames, or tried to share them between users (see Fig. 1).



**Figure 1** Internet Access authentication and policing

Internet Access used a private addressing scheme, which was not visible from the Internet, with dynamically assigned addresses from the BT Diamond IP DHCP service. Devices that could not login to the service, such as printers, cameras and vending machines, used a fixed IP variant of the service. This required a dedicated LAN connection, and needed the users to configure their own devices with a fixed IP address from the LOCOG private address range.

One of the biggest challenges surrounding the use of internet Access was predicting the capacity needs of the users. While the service was contended, this contention was applied in the network core, rather than at a venue level. As a result, network-wide Quality of Service policies had to be developed to ensure that internet access traffic was lower priority and that users did not exhaust business-critical bandwidth through streaming television (TV).

In retrospect, the widespread deployment of TVs within the estate meant that streaming was not a problem for the network. Overall, the capacity utilised by the service peaked at just over 1 Gb/s, which was about half of that expected by the contention ratio, and contention did not occur in practice.

### 3 Rate Card Direct Internet Access

The Direct Internet Access (DIA) service was designed for larger organisations with semi-permanent facilities on the Olympic venues. It had more technical flexibility and higher performance than Rate Card Internet Access, but had a lower level of protection against common threats.

DIA allowed organisations to run their own websites, mail servers and remote access systems in parallel with the Olympic facilities, at a higher bandwidth than standard Rate Card Internet Access, as the service was offered at symmetric rates of 2, 10, 50 and 100 M, with a lower 1:6

contention ratio. The 10 and 100 M services were set simply by using the speed of the port to which they were delivered, while the 2 and 50 M services used policers to ensure bandwidth was not exceeded.

The DIA service provided one or more fixed, registered IP addresses that were visible to the external Internet, and did not use any proxy or Network Address Translation. The internet connection allowed most outbound protocols and limited inbound connections to common applications.

Each customer was assigned a discrete private virtual local area network, which provided a transparent layer 2 interconnect from the access switch in the venue to the central Points of Presence (POPs). The VLANs were used to share the limited internet address space efficiently between different customers, while isolating them from one another.

When customers first arrived at the Olympic venues, there was considerable concern about the level of contention, as many of the DIA services were being used for business-critical functions, such as streaming content to internet sites or alternatively, access to company VPNs. There were several initial reports of poor performance, with the suggestion being that contention was the issue. In practice, contention never cut in on the core internet links, with the total DIA traffic across the estate peaking at less than 1 Gb/s.

It was therefore very important to be able to demonstrate the actual performance. BT therefore installed a tester into the network and was able to undertake 5 minute soak tests of an individual user's connection and hence profile the actual performance of the network. Initially, this did occasionally identify some minor configuration tweaks required to interface correctly with the customer's equipment, but more generally was able to prove that throughput issues were either in the customer's domain, or else caused by the internet itself.

## 4 Summary

Through combinations of the above services, customers were able to both create private networks that could provide connectivity to the internet, and also build custom networks within the Olympic estate that allowed centralised services to be provided to end users in any venue across the estate. The *ad hoc* solutions that this flexibility allowed required service agility as products designed for point use-cases were repurposed into full operational infrastructures within the Olympic network.

Connectivity to the internet from the Olympic estate was provided through four 10 Gb/s BT net bearers, two from each POP, each with a 5 Gb/s capacity. Traffic was separated in normal use such that all DIA traffic would use one of these connections, while the IA traffic would use another. Theoretical contention for bandwidth was implemented through management of the available bandwidth on these circuits. As stated above, in practice traffic for IA peaked at 1 Gb/s and for DIA at 800 Mb/s. As a result no contention actually occurred.



# Paper 7B – Atos – BYOD at the Games

Shailesh Chauhan<sup>1</sup> Clive Grethe<sup>2</sup>

<sup>1</sup>Atos Technical and IT Security Manager

<sup>2</sup>Atos London 2012 Account Director

E-mail: [Olympic\\_Games@atos.net](mailto:Olympic_Games@atos.net); [clive.grethe@atos.net](mailto:clive.grethe@atos.net)

## 1 Atos – BYOD at the Games

Developing an appropriate Bring Your Own Device (BYOD) strategy has been a common business challenge in recent years, requiring careful management to enable users (typically employees) to access corporate systems safely and securely from their own personal device. Whilst such a strategy can undoubtedly create additional security risks for an organisation, it is increasingly being adopted as new products and approaches enable mitigation of those risks to an acceptable level.

Atos have delivered five Olympic and five Paralympic Summer and Winter Games since being appointed Worldwide IT Partner by the International Olympic Committee (IOC) in 2001. During this time, the demand for BYOD services had grown to the point where it was inconceivable for London 2012 that the journalists would not have ready access to Games information systems from their workplace in a competition venue, the Main Press Centre or hotel room using their own laptop. This also held true for many of the other key stakeholder groups attending the Games, including the broadcasters, International Sporting Federations, athletes and other members of the Olympic Family.

To meet this demand, the services delivered for the London 2012 Olympic and Paralympic Games were a close integration of systems from LOCOG, Atos and BT that together created a coherent, easy-to-use BYOD environment. This paper outlines the solutions provided by Atos to make these services available, enabling journalists to fill their news stories with the latest facts and figures from the Games and rapidly publish them for consumption by a worldwide audience.

## 2 Identity management

The two critical services that journalists required during the Games were internet access and the new Atos myInfo<sup>+</sup> application. A number of aspects of these two services are important to highlight at this point (see Table 1).

Table 1

myInfo <sup>+</sup>	A chargeable service from LOCOG, delivered by Atos. Access to myInfo <sup>+</sup> was bundled with standard grade Internet access and the application included a number of user-configurable features such as Email and SMS text alerts
Rate Card Internet	A chargeable service from LOCOG, delivered by BT, the Official Communications Services Partner and described more fully in their accompanying paper. Basic and standard grades of service were available and they could be purchased for variable periods of time, for example, Olympics or Paralympics

During the early planning phases of the project, the intended characteristics of these two services highlighted the need for an Identity Management (IDM) solution that would limit users to the service(s) that they had purchased, without being too onerous and causing frustration. LOCOG contracted Atos to deliver this IDM solution and the high-level requirements were determined as follows:

- Self-service user account provisioning, based on a single-use activation code issued following placement of order;
- Self-service password management capability;
- Accessible directly from venues as well as externally from the internet, to encourage early registration prior to arrival;
- Per user identification of the specific service(s) purchased and start/end dates;
- Directory service allowing LDAPS queries from the rate card internet access proxy infrastructure;
- Synchronisation with the Atos myInfo<sup>+</sup> user authentication database;
- Disaster recovery corresponding to that of the internet access and myInfo<sup>+</sup> services.

Following a period of development and testing, the Atos Rate Card IDM solution was first trialled by journalists attending the London Prepares series test events in early 2012. The positive feedback from the journalists for this new Olympic service resulted in a number of refinements to improve the user experience through simplification, including greater freedom for user passwords and a reduction in the number of security questions, the latter being necessary for the self-service password reset function. Subsequently, in an approach intended to take the solutions out of the lab and further prove them in a ‘real-world’ environment before the Games, LOCOG worked with BT and Atos to replace the existing guest wireless service with the rate card service. This required guest users to register via

the Atos IDM self-service portal and authenticate using the combined BT/Atos infrastructure and overall this proved to be an ideal way of testing the Rate Card IDM and internet services before the arrival of the Olympic Games.

Guest use of the solution is evident in the account registrations that occurred well before the Games, but as shown in Fig. 1 below, the demand for accounts increased considerably in the final 10 days leading up to the opening ceremony on the 27th July.

Other statistics captured during the Olympic Games indicated that the Rate Card Internet service reached a daily peak of approximately 2500–3000 users during the Olympics, all of whom were authenticated against the Atos IDM solution.

### 3 myInfo<sup>+</sup>

The Info system has long been the key essential information portal and the mainstay of the Olympics and Paralympics, serving the needs of the press, broadcasters, athletes, officials and other members of the Olympic Family by providing a whole range of information, including:

- Competition Schedules
- Athlete Biographies
- Medal rankings by country
- Sport records – Olympic, Paralympic, World Championship and Personal Bests
- Results

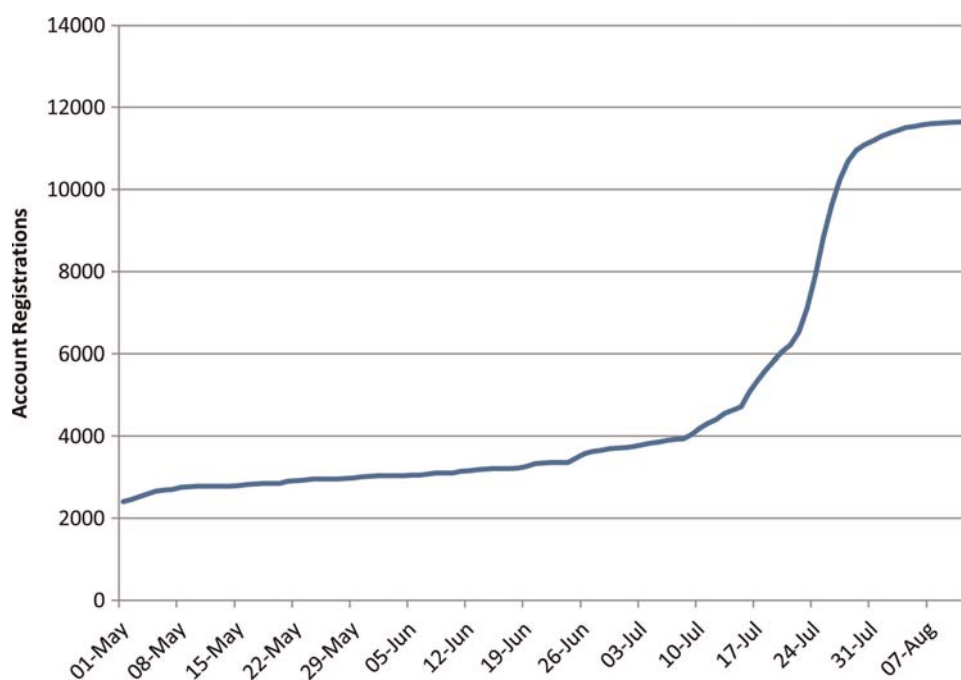


Figure 1 Rate Card IDM Cumulative Account Registrations

- The latest Olympic and Paralympic news
- Weather by venue
- Transport information

Traditionally made available on dedicated kiosk PCs in specific 'Back of House' locations within the venues, Info is known as the definitive source of Olympic and Paralympic information and considered an essential tool for accredited journalists as they compile their news stories.

Building on the experience of delivering Olympics and Paralympics Info systems since being appointed Worldwide IT Partner by the IOC in 2001 and following requests from the press community, Atos developed a new version for the London 2012 Games, called Info<sup>+</sup>. However, London 2012 also saw the introduction of myInfo<sup>+</sup> for the very first time, which was accessible from a personal device via the internet or directly from venue.

Both the Info<sup>+</sup> and myInfo<sup>+</sup> systems advanced the service beyond previous Olympic and Paralympic Games by including features such as near real-time results, but myInfo<sup>+</sup> went further and enabled users to:

- Download PDF files containing results and other information for their own use;
- Link to external sites such as the IOC, London 2012 and the International Sporting Federations via pre-defined hyperlinks;
- Customise the homepage, for example to highlight specific countries of interest;



**Figure 2** Info<sup>+</sup> and CIS Kiosk

- Configure email and SMS text alerts, to provide notification of events such as when a new world record was broken.

The availability of PDF files from myInfo<sup>+</sup> was important in terms of the accompanying cloud-based print service implemented by LOCOG, known as myPrint. This allowed users to submit a file via email and then collect it from the most convenient printer to them.

The introduction of myInfo<sup>+</sup> substantially reduced the footprint of Info<sup>+</sup> in comparison with previous Games;



**Figure 3** Main Press Centre work area

**Table 2** Info<sup>+</sup> and myInfo<sup>+</sup> usage

Description	
Info <sup>+</sup> & myInfo <sup>+</sup> peak page views per day*	430,000
myInfo <sup>+</sup> total user accounts	6100
myInfo <sup>+</sup> average unique users per day	5000
myInfo <sup>+</sup> average user behaviour per day	3 visits of 20 min each

\*This is a combined figure, however myInfo<sup>+</sup> represented the higher proportion

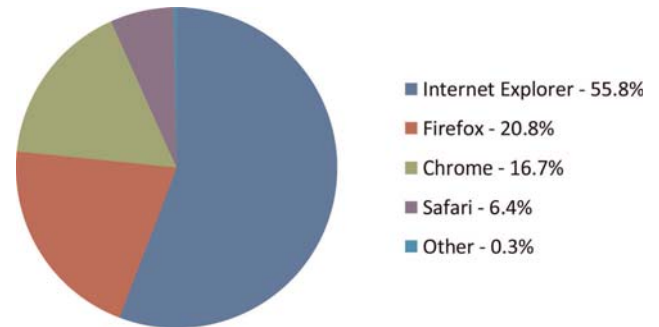
however, there was still a place in London 2012 for the convenience of an Info<sup>+</sup> machine that was always booted up and ready for use. Fig. 2 shows a floor-standing Info<sup>+</sup> kiosk ready for installation; alongside it is a Commentator Information System (CIS) kiosk, which delivered real-time results across all Olympic and five Paralympic sports in another first for London 2012.

As mentioned previously, journalists are a key user group for myInfo<sup>+</sup> and the Main Press Centre provided an integrated working environment to meet all of their needs. Fig. 3 shows the Main Press Centre in operation, with journalists accessing the Internet and myInfo<sup>+</sup> services from their laptops, desktop Info<sup>+</sup> PCs available for additional convenience and myPrint printers just visible to the left of the picture.

A range of statistics were captured reflecting the use of the Info<sup>+</sup> and myInfo<sup>+</sup> services during the London 2012 Olympic and Paralympic Games and these are shown in Table 2. These statistics clearly show the importance of the services, with 82% of the total users accessing the site for an hour every day until close to the end of the Games.

## 4 Device compatibility

The London 2012 Games presented a particularly difficult proposition for the Atos IDM and myInfo<sup>+</sup> services in terms of device compatibility. With journalists and others arriving from around the world with all manner of device and configuration, the two services could not be unnecessarily restrictive and it was essential to support all mainstream browsers as a minimum. The issue of compatibility was kept under review throughout the programme and finally, in agreement with LOCOG,



**Figure 4** myInfo<sup>+</sup> browser use

appropriate versions of Internet Explorer, Firefox, Chrome and Safari were selected. Compatibility testing was carried out using a variety of devices and browser combinations to ensure that the services would operate correctly across them. Fig. 4 shows the breakdown of different browsers used to access myInfo<sup>+</sup> during the London Games and it is reassuring to see such a small percentage outside of the supported range.

## 5 Conclusion

LOCOG, Atos and BT worked in close partnership to deliver an integrated set of services for key client groups at the London 2012 Olympic and Paralympic Games, enabling those users to have ready access to the latest news and results whenever and wherever they needed it, from the convenience of their own device. The London Games have provided an excellent proving ground and showcase for the BYOD concept to Government and private sector, and have set a new benchmark for future Games.

# IET Digital Library

## Building the best in engineering research and information

**Keep at the forefront of research** by accessing a portfolio of information in a range of engineering fields on the recently re-launched IET Digital Library.

Improved navigation and a refreshed appearance makes it even easier to find the essential engineering research that you need, in the format that you need it.

### Includes access to

- 180,000 research journal and magazine articles
- 3,000 eBook chapters
- 1,300 conference publications
- Over 70,000 archive articles dating back to 1872

To build your unique package of engineering and technology research and to take a look at our improved site, visit: -

[www.ietdl.org](http://www.ietdl.org)



# Make it personal



## ICT Technician (ICTTech)

If you want to make it **big** in your industry, choose Professional Registration through the IET. An **ICTTech** is an internationally recognised qualification which will enable you to focus on growing your individual skills and your reputation with colleagues and employers.

You're looking for a qualification that says all the right things. An **ICTTech** will make a big statement about your skills and professionalism.

Make it **happen** with Professional Registration from the IET

[www.theiet.org/icctech](http://www.theiet.org/icctech)

# Take your business further, faster



## Join the British Business Club

The British Business Club is an exciting new resource available to help you make the most of business networking and activity around the London 2012 Olympic and Paralympic Games and other major sports events now and in the future.

An online, one-stop shop, the British Business Club brings you up-to-date details of networking events, business activity, news and potential partners around international sports events,

boosting the opportunities for UK companies to make valuable international business connections.

As well as providing access to information, the British Business Club enables members to promote relevant business events. Plus members will benefit from exclusive offers.

Membership of the British Business Club is free. You can join wherever you are based in the world.



Get in the fast lane – register now at:  
[www.britishbusinessclub.org](http://www.britishbusinessclub.org)



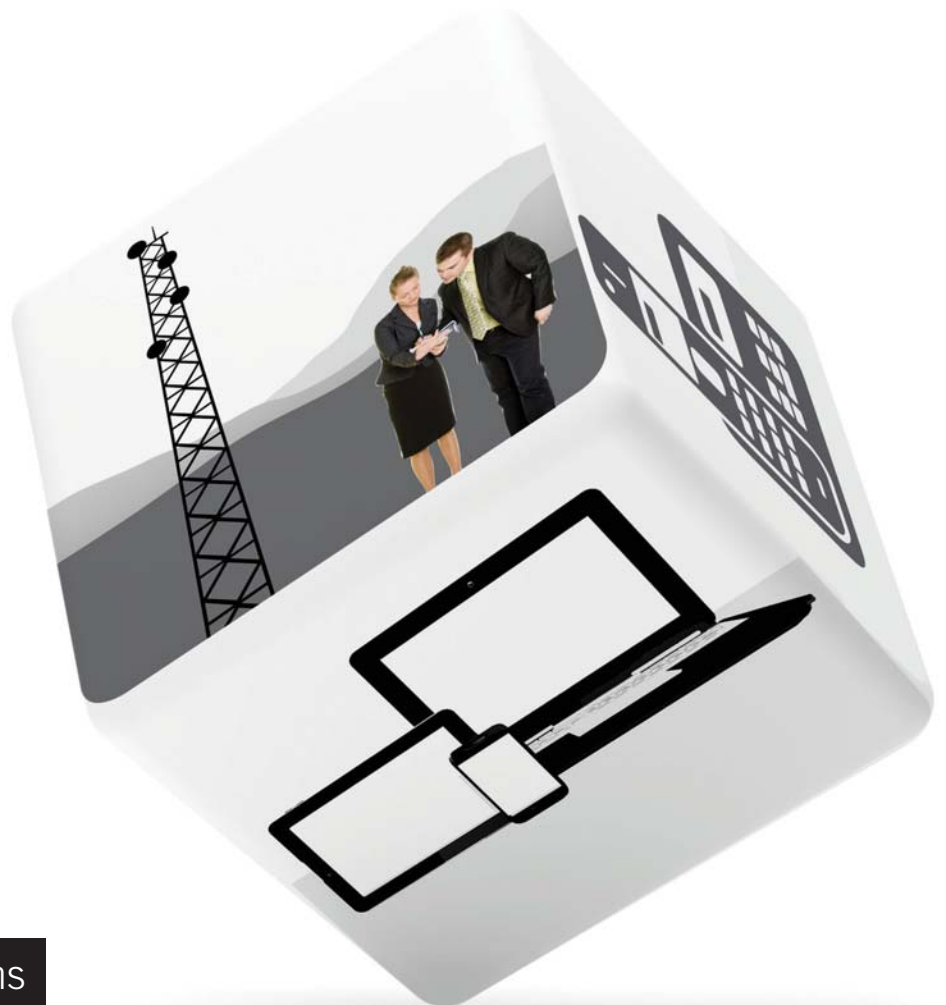
Follow us on twitter:  
[@britbizclub](https://twitter.com/britbizclub)

In partnership with



# Connecting tomorrow, digitally

The **Information and Communications Sector** offers access to a range of products and services covering news, events, communities, professional development and support designed to help you enhance your knowledge and career.



**Get involved...**

[www.theiet.org/info-comms](http://www.theiet.org/info-comms)