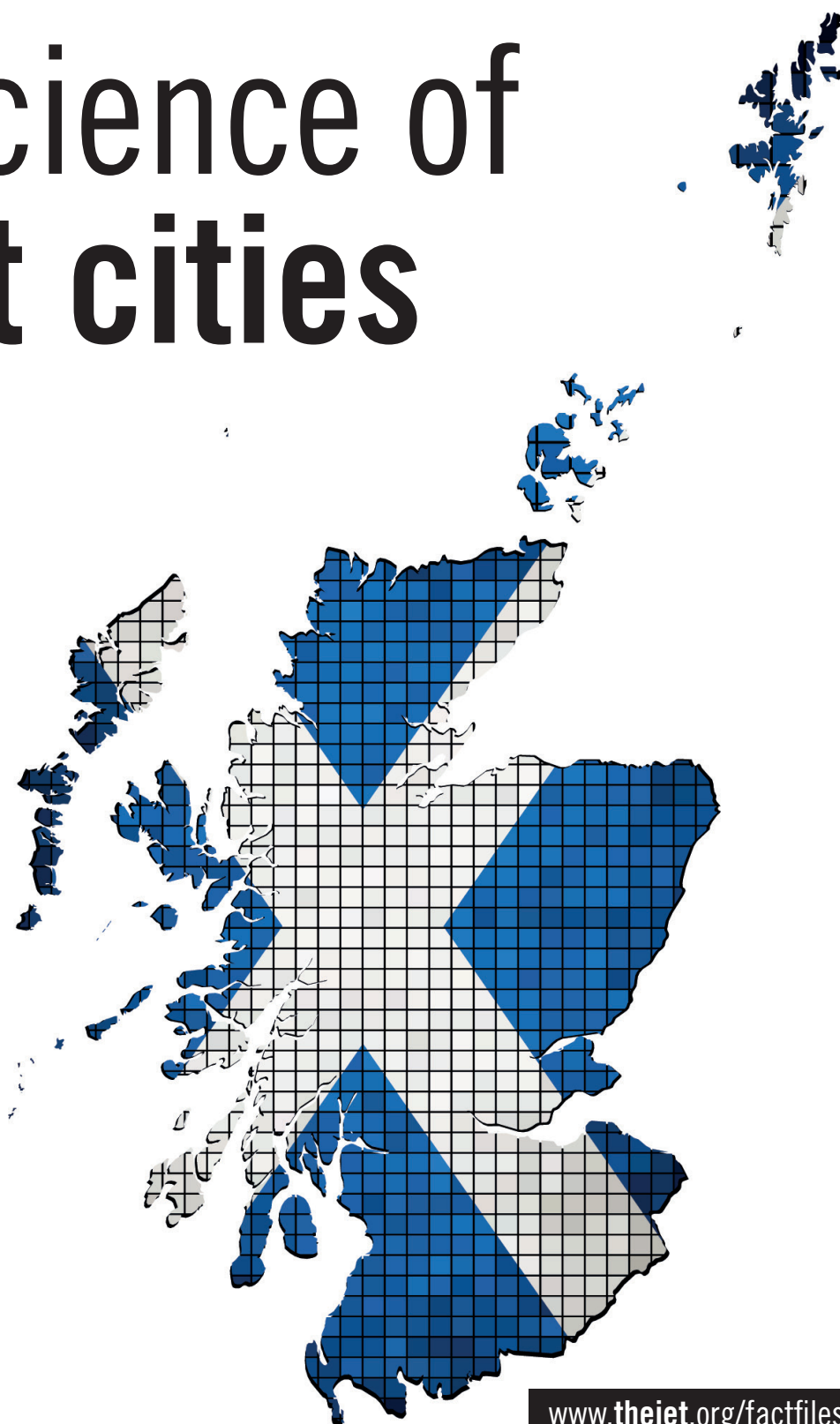**IET** The Institution of
Engineering and Technology

The science of Smart cities

An Engineering
Policy Group
Scotland Holyrood
Briefing given
at the Scottish
Parliament on 12
November 2014

The science of smart cities

This document comprises material presented during an Engineering Policy Group Scotland 'Holyrood Briefing' on 12th November 2014, at the Scottish Parliament.

Host and Chairperson: Clare Adamson MSP, Co-convener of the Cross Party Group on Science and Technology.

Speaker: Professor Piyushimita Thakuriah (Vonu) - Professor of Urban Studies, University of Glasgow

Professor Thakuriah kindly agreed to allow the reproduction of her PowerPoint presentation herein.

The Science of Smart Cities

Piyushimita Thakuriah (Vonu)
Director, UK ESRC Urban Big Data Centre
Professor of Urban Studies
Halcrow Chair of Transport
UNIVERSITY OF GLASGOW

November 12, 2014

University of Glasgow — Urban Big Data Centre — An ESRC Data Investment

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Format of Presentation

- Urban Big Data Centre
- Smart Cities – Introduction
- Major Aspects
- Approaches and Applications & the Science of Smart Cities
- Challenges

Urban Big Data Centre

- **Interdisciplinary research centre** bringing together urban social sciences and data sciences to promote *innovative methods* and *complex urban data* to:
  - Support **research, practice and outreach** on social, behavioural and environmental challenges facing cities with focus on:
    - **Strategic Themes** - dynamic resource management; social exclusion; lifelong learning; migration; activity patterns; civic and urban engagement; attitudes, lifestyle and beliefs
    - **Multiple Urban Sectors**: transportation, housing, education, economic development, environment, energy
  - Support **effective and responsible use of heterogeneous urban data** by academics, public and private sector analysts, citizen-scientists with a focus on Open Data, open source technologies and software

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E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL — University of Glasgow

University of BRISTOL — THE UNIVERSITY of EDINBURGH — University of Reading

UNIVERSITY OF CAMBRIDGE — The University Of Sheffield — UIC UNIVERSITY OF ILLINOIS AT CHICAGO

UBDC Portfolio

- Data Products
- Data Services
- Research
- Outreach & KE
- Training

Disciplines
- Urban planning & policy
- Statistics
- Economics
- Computer science
- Education
- Geography
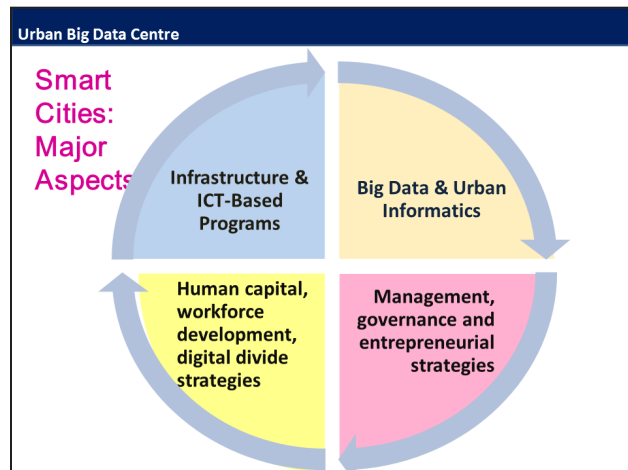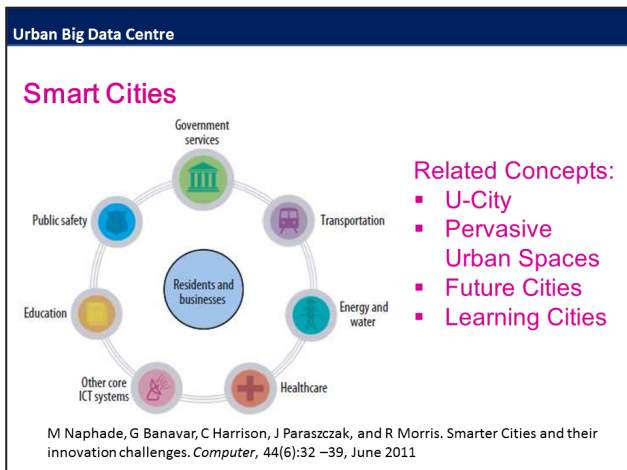- Mathematics
- Civil engineering

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Smart Cities: Major Aspects

- Resource management with a focus on using Information and Communication Technology
- Connectivity in infrastructure emphasizing coordination among functionalities and integration in service delivery
- Urban development strategy focussed on regeneration and innovation
- Citizen engagement and civic participation
- Open data, portals and Web 2.0
- Networks of civic technologies, independent ICT developers and citizen scientists
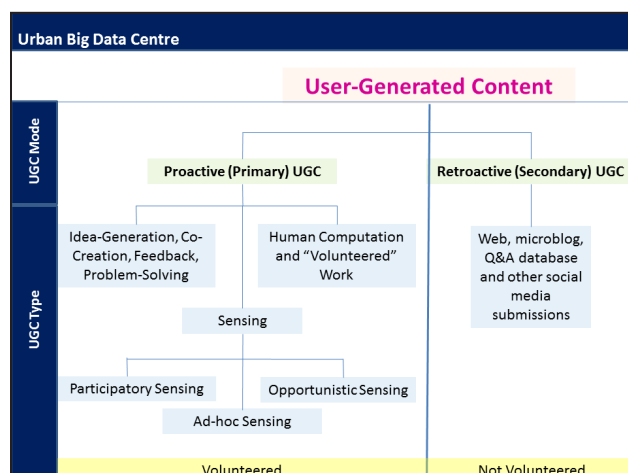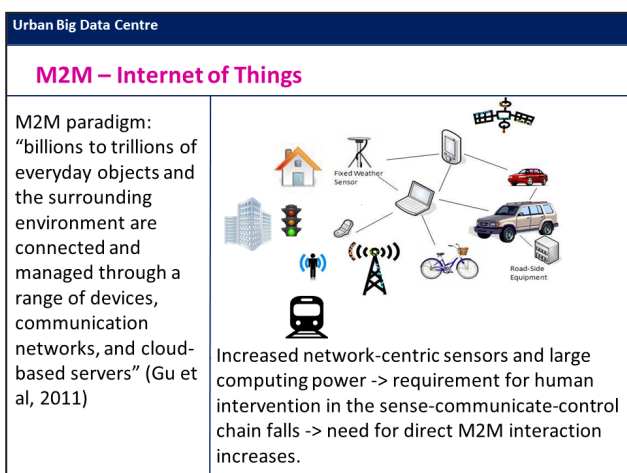
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Smart Cities

Related Concepts:
- U-City
- Pervasive Urban Spaces
- Future Cities
- Learning Cities

M Naphade, G Banavar, C Harrison, J Paraszczak, and R Morris. Smarter Cities and their innovation challenges. *Computer*, 44(6):32 −39, June 2011

Smart Cities: Major Aspects

- Infrastructure & ICT-Based Programs
- Big Data & Urban Informatics
- Human capital, workforce development, digital divide strategies
- Management, governance and entrepreneurial strategies

Infrastructure and ICT-based Programmes

- Intelligent Transportation Systems (ITS)
- Structural Health Monitoring for asset management and condition monitoring
- Location-Based Services (& Location-Based Social Networks)
- Open Government Initiatives
- Connected systems:
  - Connected vehicles with situational awareness & in-vehicle monitoring
  - Connected cars (Vehicle-to-Vehicle V2V)
  - Connected Infrastructure (Vehicle-to-Infrastructure V2I)
  - Connected energy (Vehicle-to-Grid V2G)
  - Smart and Connected systems (weather, emergency, health management)

What is Big Data? – Examples of Popular Definitions

- "Data that exceeds the processing capacity of conventional database systems".

  Example: 400 million tweets per day, 170 billion+ tweets in Library of Congress data archive

- "Differs from traditional data via three Vs: Volume: Size of the data"
  Velocity: Rate in which data flows in
  Variety: Structured as well as unstructured data

  Messy: 80% of analyst's time spent on data cleaning

M2M – Internet of Things

M2M paradigm: "billions to trillions of everyday objects and the surrounding environment are connected and managed through a range of devices, communication networks, and cloud-based servers" (Gu et al, 2011)

Increased network-centric sensors and large computing power -> requirement for human intervention in the sense-communicate-control chain falls -> need for direct M2M interaction increases.

User-Generated Content

UGC Mode

UGC Type

Proactive (Primary) UGC

Retroactive (Secondary) UGC

Idea-Generation, Co-Creation, Feedback, Problem-Solving

Human Computation and "Volunteered" Work

Web, microblog, Q&A database and other social media submissions

Sensing

Participatory Sensing

Opportunistic Sensing

Ad-hoc Sensing

Volunteered

Not Volunteered

Administrative Data & Private Data for Urban Analysis

- **Administrative data linkage programs yield substantial information on cities**
  - Examples: ESRC-funded UK Administrative Data Research Centers
  - US Census Bureau estimates saving $2 billion if it uses administrative records to supplement door-to-door visits to non-respondents, supporting quality control, or helping to evaluate the quality of the census
- **Private sector transactions data or customer databases**
- **Extremely challenging issues – data confidentiality and lack of informed consent**

Smart City Big Data Infrastructure

- Administrative data eg, crime, transport, property taxes, energy, public health, housing etc - Open Government initiatives leading to large longitudinal or repeated cross-sections of such data
- Privately-held transactions or other data or confidential government data records which are often not readily accessible
- Surveys and censuses
- "Synthetic" outputs from urban and regional planning models & simulations
- Infrastructure-based sensors and Machine-to-Machine (M2M) communications
- User-Generated Content (UGC)

BIG QUESTIONS (a far from complete list)

- How to **operate** cities effectively and efficiently
- Fine-grained understanding of **demographic drivers**
- Analysis of **relationships among historically siloed urban sectors** – eg. Health, employment and migration; education and transportation
- Understanding what makes the economy resilient and strong – how to develop **shock-proof cities**
- Using linked, longitudinal data, understanding **how different cities recovered from man-made or natural disasters**
- Understanding **behavioral interventions** needed for healthy or sustainable behavior and technology and support services needed
- How to build **ecosystems for urban innovation** using ICT and networks
- **Lifelong learning strategies** and models of governance needed to prepare citizens for wholesale transformation to ubiquitously information-based society
- How **social exclusion** historically evolved over time as a result of myriad agents and policies and practices

Urban Informatics

Analyzing, visualizing, understanding, interpreting such structured and unstructured data on cities (city-regions) for:

- Dynamic resource management
- Knowledge discovery and understanding
- Urban engagement, civic participation
- Urban planning, policy analysis and design

Emerging Information Users	**Traditional Urban Data Users**	Planning organizations Operational agencies Research organizations and universities Consulting firms
Urban Digital Infomediaries - 4 Major Groups with 10 Urban Digital Infomediaries Thakuriah et al (2014) *Emerging Urban Digital Infomediaries and Civic Hacking in an Era of Big Data and Open Data Initiatives*	**General-purpose ICT Infomediaries** - Smart City Companies - Multiple-service ICT Companies **Urban Information Service Provider Infomediaries** - City Information Services - Location-Based Services - Location-Based Social Networks **Urban Open and Civic Data Infomediaries** - Open Data Organizations - Civic Hacking Organizations - Community-Based Information Service Organizations **Independent and Open Source Developer Infomediaries** - Independent App Developers - Open Source Developers	

Disciplines Involved

- Professional urban disciplines (urban planning, public policy, public administration)
- Urban social scientists (economics, geography, education etc)
- Computational social scientists
- Data scientists (computer science, statistics, other informatics)
- Architecture and urban design
- Arts (digital humanities, linguistics)
- Health scientists
- Civil infrastructure engineering

Science of Smart Cities

Data management and use (communications, sensor networks, Sensor Fusion, data linkage, resource discovery, standards, ontologies, data sharing methods, Privacy-Enhancing Technologies, security, Information retrieval and extraction)

Urban Analytics (using linked urban data for urban and regional modeling, complex systems analysis, agent-based modeling, decision support systems, long-term impact assessment models, machine learning, specialized KDD methods: eg, Geographic Knowledge Discovery, trajectory mining, online location-based social network analysis, predictive analytics)

Management and Institutional Issues (workforce development strategies, governance models, strategies for privacy protection and digital citizenship)

Urban Information Infrastructure - Does better information allow better urban decision-making?

- Planning
- Policy Making
- Governance
- Operations
- Management
- Progress on the urban agenda, eg, sustainability, social inclusion

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Challenge 1 - More information and connectivity DOES NOT EQUAL better governance – depends on data quality, technical processes to extract information and involvement of planning & policy stakeholders from project conception through design, implementation and operations

Challenge 2 – Connecting **LINKED** data to decision making – and more importantly – ACTION! This does not happen automatically but better data can open doors and stimulate joint action.

Challenge 3 – Connecting data to better life in the city, social equity and inclusion, better learning environments and more engaged citizenship.

Challenge 4 - Addressing limitations due to digital divide and establishing innovative ICT-based approaches to increase capacity for involvement and inclusion.

Challenge 5 – Meet significant challenge posed by potential privacy risks and data confidentiality.

Challenge 6 – Workforce development , skills gap and project management including ICT-based project leadership.

Challenge 7 – Expedite timeline from innovation to actual deployment.

US National Science Foundation-sponsored Workshop on Big Data and Urban Informatics – Statistics

90 completed full-paper submissions. 68 accepted presentations

Asbtract Submission Co-Authors by Country
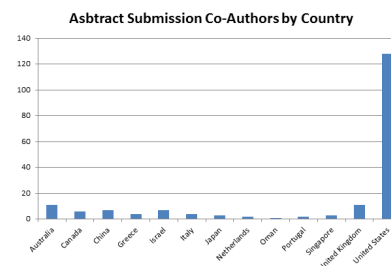
Partner with us:
We support policymakers, businesses, third sector organisations and everyday citizens to harness the potential of big data to develop solutions for environmentally sustainable, economically resilient and socially just cities.

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