Smart Cities: Technological Challenges and Issues

RAJ JAIN

Washington University in Saint Louis
Saint Louis, MO 63130, Jain@cse.wustl.edu

IEEE CS Keynote at ADCOM 2015,
Chennai, India, September 19, 2015

These slides and video recording of this presentation are at:
http://www.cse.wustl.edu/~jain/talks/smrtcit.htm

Overview

1. What is a smart city? Why now? How?

2. City IQ: How to measure smartness of a city

3. Smart Cities in India and RoW (Rest of the World)

4. Challenges: Non-Technical and Technical

5. What can we (researchers) do?

City Confusion!

Cyber City

Intelligent City

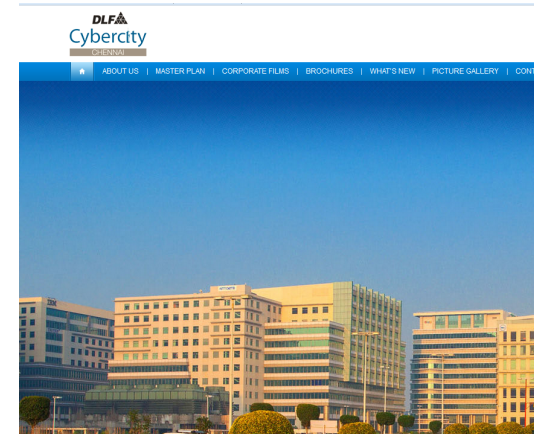Digital City

Eco-City

Knowledge City

Information City

- ❑ Cyber Cities, Digital Cities, Second life Cities, Simulated Cities, Intelligent Cities, Knowledge Cities, Sustainable Cities, Talented Cities, Wired Cities, Digital Cities, Eco-City, Electronic Communities, Cyber Ville, Information Cities, …

City Confusion (Cont)
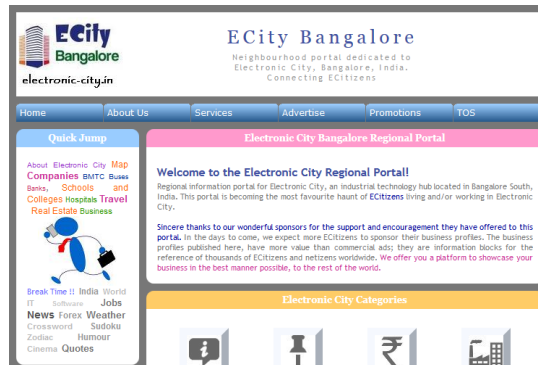
Electronic City, Bangaluru

DLF Cybercity, Chennai

Adamas Knowledge City, Kolkata

Digital City, Coimbatore

Smart Everything

Smart Watch

Smart TV

Smart Car

Smart Health

Smart Home

Smart Kegs

Smart Space
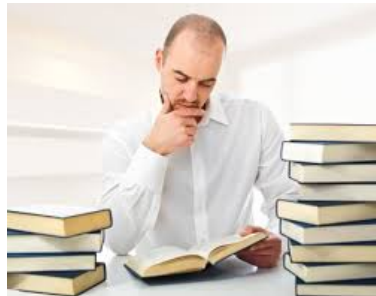

Smart Industries

Smart Cities

What's Smart?

❑ Old: Smart = Can think ⇒ Can compute
❑ Now: **Smart** = Can find quickly, Can Delegate
  ⇒ Communicate = **Networking**
❑ Grid vs. Smart Grid, Meter vs. Smart Meter, Car vs, Smart Car, Home vs. Smart home. **Smart = Connected**
❑ Smart City vs. City

Think   Communicate   Not-Smart   Smart

What's the Problem?

❑ City = 100,000+ population

❑ Over 50% of world population lives in cities and growing. By 2050, 75% will live in urban areas

❑ Mega city = 10+ million population

  ➢ 11 in Asia, 4 in Latin America, 2 in Africa, 2 in Europe, 2 in North America = 21 Total in 2010

  ➢ 29-37 in 2025 with 14-22 in Asia

❑ City population is growing much faster than resources
  $\Rightarrow$ Need **sustainable** ways to **manage** resources for city living: Water, Electricity, Housing,…$\Rightarrow$ Quality of life $\Rightarrow$ Smart City

Ref: V. Aillaud, "Digital economy and smart métropolies : a joint future? ," http://www.europmetrocci.eu/l/Portals/0/EuropmetrocciDocuments/london%2030-31%20october%202013/PARIS%20Smart-cities%20Valerie%20AILLAUD.ppt
J. Bélissent, "Getting Clever About Smart Cities: New Opportunities Require New Business Models," Forester, Nov 2010, 33 pp., http://193.40.244.77/iot/wp-content/uploads/2014/02/getting_clever_about_smart_cities_new_opportunities.pdf

Old vs. New

❑ Governments: Last to adopt new technologies

❑ Amazon, Face book, Google: Use the latest technologies
Internet, smart phones, tablets, RFID, sensors, social media

❑ Smart ⇒ Run a city like Amazon.com
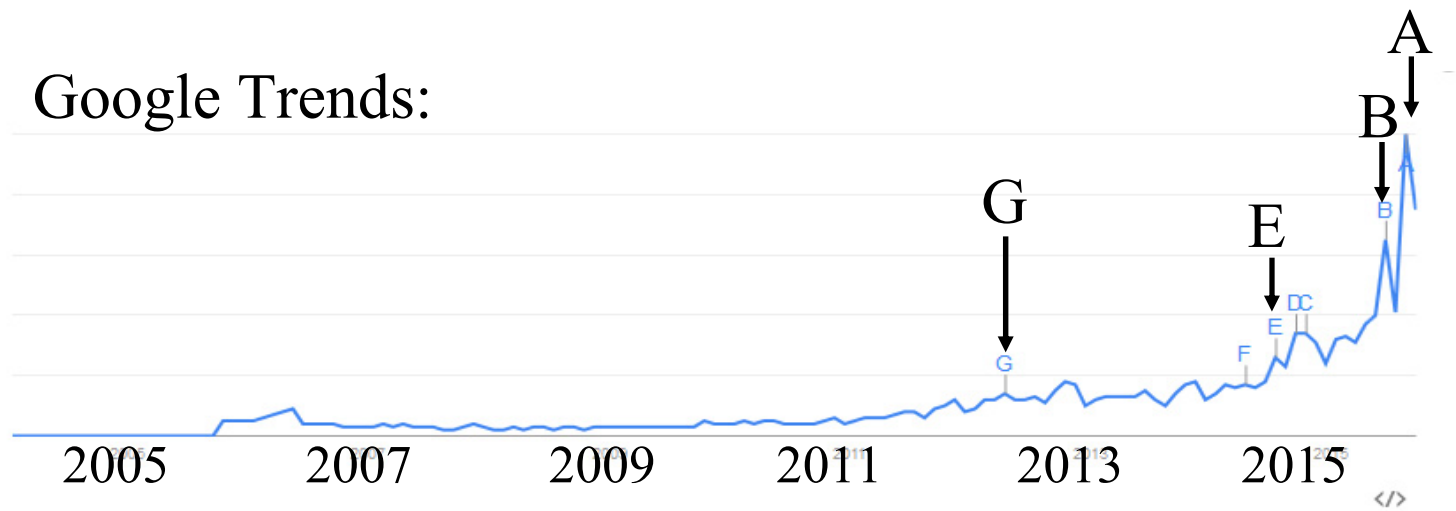User driven, Dynamic, Real-time, Technology-oriented

Numerous offices

Single interface for all services

Is This a New Problem?

❑ Google Trends:

❑ G (April 5, 2012): Italian national observatory launches "Smart Cities" program

❑ E (July 11, 2014): Rs. 7,060 crore for 100 smart cities (BJP Election Manifesto)

❑ B (June 30, 2015): Cisco launches IoT systems to make smart cities smarter

❑ A (August 27, 2015): List of 98 smart cities announced in India

❑ 1992: World Foundation for Smart Communities –

Smart City = Technology, Innovation, Globalization ⟹ 33 yr old problem

Ref: Gibson, D.V., Kozmetsky, G., Smilor, R.W. (eds.), "The Technopolis Phenomenon: Smart Cities, Fast Systems, Global Networks," Rowman & Littlefield, New York (1992)

Why Are We Solving the Problem Now?

- ❑ $27.5 billion annual revenue in smart city technology by 2023
  $174 billion investment by 2023

- ❑ Cisco, Intel, Huawei, IBM, Fujitsu, SIEMENS are all selling ICT for smart cities

- ❑ Central government in India will spend ~$7 billion for smart cities in the next five years ⇒ Theme for ADCOM 2015 ⇒ ADCOM 2015 selected Chennai instead of Bangaluru
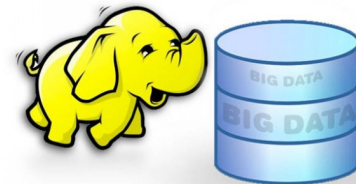
Ref: Navigant Research, "Smart Cities," https://www.navigantresearch.com/research/smart-cities

Smart Cities Enablers

Smart Services $\Rightarrow$ Smart Cities

ICT

Infrastructure

A 7-Layer Model of Smart Cities
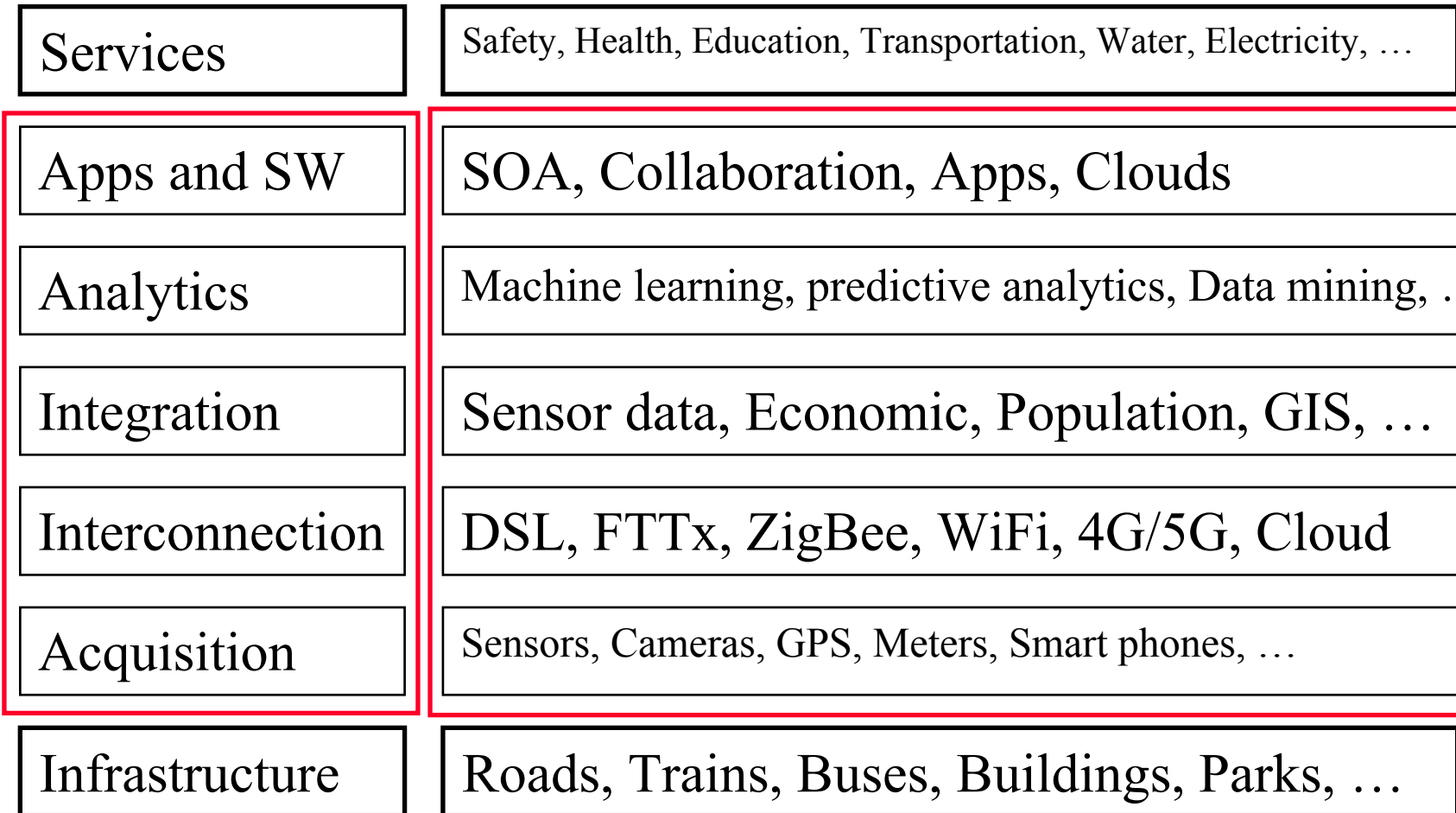
Services	Safety, Health, Education, Transportation, Water, Electricity, …
Apps and SW	SOA, Collaboration, Apps, Clouds
Analytics	Machine learning, predictive analytics, Data mining, …
Integration	Sensor data, Economic, Population, GIS, …
Interconnection	DSL, FTTx, ZigBee, WiFi, 4G/5G, Cloud
Acquisition	Sensors, Cameras, GPS, Meters, Smart phones, …
Infrastructure	Roads, Trains, Buses, Buildings, Parks, …

ICT

Washington University in St. Louis   http://www.cse.wustl.edu/~jain/talks/smrtcit.htm   ©2015 Raj Jain

ICT for Smart City

1. **Acquisition** (Sensors): Provide real-time information about usage, availability, demand, state of resources

2. **Interconnection** (Networking): FTTH, 4G LTE, IP multimedia system (IMS)

3. **Integration**: Combine sensor data with other city data such as geographical information, economic data, population data.

4. **Analytics**: Predictive analytics, machine learning, data mining

5. **Apps and Software**: Cloud Computing: Computation, storage, and ubiquitous accessibility, Service oriented Architecture (SOA)

> ICT is the heart of Smart Cities

Smart Services: Examples

❑ London's Datastore: Jobs, Waste, Crime, Visitors, …
All open to public, http://data.london.gov.uk/

❑ New Songdo City, Incheon, South Korea: All city services
available via Internet, video conferencing,
http://www.songdo.com/

❑ Delhi police app to report crime
55,000 reports in 6 months

❑ In Melbourne, All trees have been
assigned ID numbers so that public
can report tree problems, overgrown
branches, fallen trees, etc.
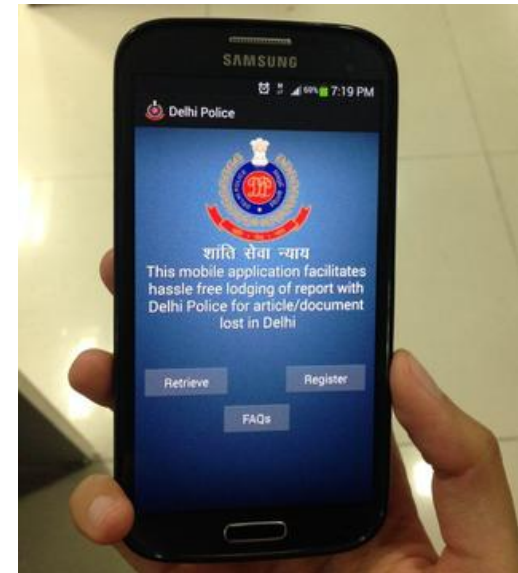
Smart Trees
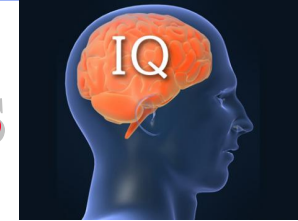
To: Golden Elm, Tree ID 1037148
21 May 2015
I'm so sorry you're going to die soon. It makes me sad when trucks damage your low hanging branches. Are you as tired of all this construction work as we are?

❑ Trees are getting email messages

City IQ: Benchmark for Smartness

❑ ISO 37120:2014 Sustainable Development of Communities: Indicators for City Services and Quality of Life

❑ Using 17 themes and 100 indicators for city services and quality of life, World Council of City Data (WCCD) give a city one of five levels.

ISO 37120 ASPIRATIONAL WCCD 2014	ISO 37120 BRONZE CERTIFIED WCCD 2014	ISO 37120 SILVER CERTIFIED WCCD 2014	ISO 37120 GOLD CERTIFIED WCCD 2014	ISO 37120 PLATINUM CERTIFIED WCCD 2014
30-45 Aspirational	46-59 Bronze	60-75 Silver	76-90 Gold	91-100 Platinum

Washington University in St. Louis http://www.cse.wustl.edu/~jain/talks/smrtcit.htm ©2015 Raj Jain

List of Smart Cities

❑ World Council on City Data (WCCD): Partial List

City	Country	Year	Level
Amsterdam	Netherlands	2014	Aspirational
Helsinki	Finland	2014	Aspirational
Johannesburg	South Africa	2014	Aspirational
Shanghai	China	2014	Aspirational
Buenos Aires	Argentina	2014	Gold
Makkah	Saudi Arabia	2014	Gold
Melbourne	Australia	2014	Gold
Barcelona	Spain	2014	Platinum
Boston	United States of America	2014	Platinum
Dubai	United Arab Emirates	2014	Platinum
London	United Kingdom	2014	Platinum
Rotterdam	Netherlands	2014	Platinum
Toronto	Canada	2014	Platinum
Los Angeles	United States of America	2015	Platinum

Ref: http://www.dataforcities.org/registry

Areas Measured by ISO 37120:2014

1. Economy
2. Education
3. Energy
4. Environment
5. Finance
6. Fire and emergency response
7. Governance
8. Health
9. Recreation
10. Safety
11. Shelter
12. Solid waste
13. Telecommunications and innovation
14. Transportation
15. Urban planning
16. Wastewater
17. Water and sanitation

Indicators

❑ Indicators: Quantitative, qualitative, or descriptive measures 47 of 100 are core.

❑ Core (Required), Supporting (Recommended), Profile (Informative) indicators

❑ Example: Education

1. % of female school aged population enrolled in schools (core)
2. % of students completing primary education: survival rate (core)
3. % of students completing secondary education: survival rate (core)
4. Primary education student/teacher ratio (core)
5. % of male school-aged population enrolled in schools (supporting)
6. % of school-aged population enrolled in schools (supporting)
7. # of higher education degrees per 100,000 population (supporting)

Washington University in St. Louis   http://www.cse.wustl.edu/~jain/talks/smrtcit.htm   ©2015 Raj Jain

Smart Cities Research in US

❑ White House "Smart Cities Week" (Sep 15-18, 2015)

❑ $40 M Research funding from NSF

  ➢ Gigabit applications healthcare, energy, transportation, manufacturing, education and learning, and public safety.

  ➢ Cyber physical systems

❑ Make Broadband construction faster:

  ➢ Websites to list all federal assets available for broadband

  ➢ Broadband installation during new road construction

❑ US Ignite Program

  ➢ Multi-gigabit connections in and between cities

  ➢ Multi-gigabit Applications ⇒ Uncompressed video

Ref: NSF, "Cultivating Smart and Connected Communities," http://nsf.gov/news/news_summ.jsp?cntn_id=136253
Smart City Week, http://www.smartcitiesweek.com/

Who is interested in Smart Cities?

❑ Google Trends:

	Region| City
India	100
Italy	33
Spain	30
Belgium	26
Netherlands	13
United Kingdom	13
United States	9

❑ India >> Europe >> USA

100 Smart Cities in India
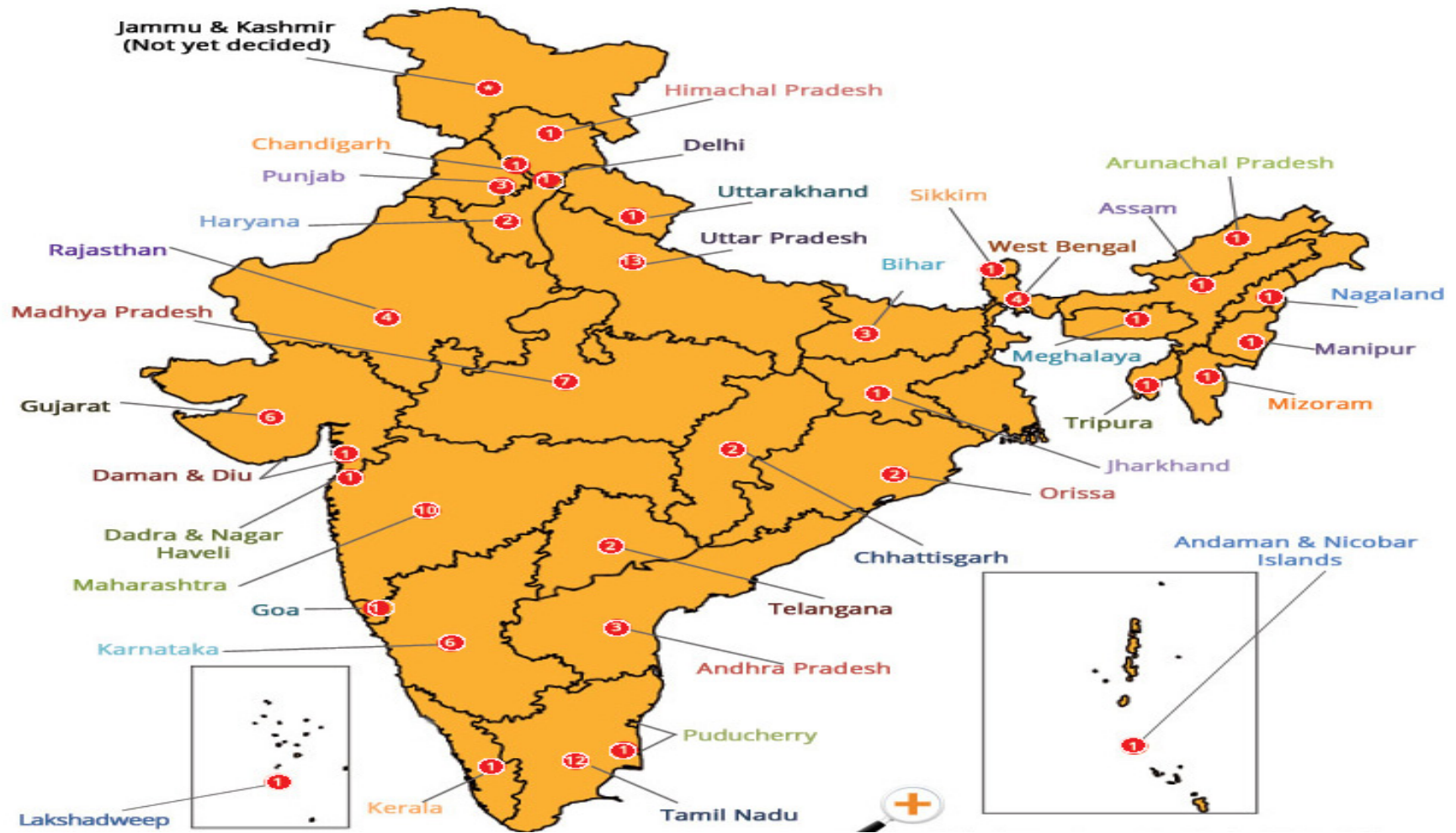
Cities in India

- Over 50% of world population lives in cities.
  31% of India's population lives in cities
  Will be 40% by 2030

- 63% of India's GDP comes from cities
  Will be 75% by 2030

- Rs. 48,000 crores (~$7 Billion) over 5 years
  $\Rightarrow$ Rs. 100 crore/year/city
  Matching amount from states
  More from partnerships

Washington University in St. Louis   http://www.cse.wustl.edu/~jain/talks/smrtcit.htm   ©2015 Raj Jain

Challenges

1. **Financing**: Self-sustaining $\Rightarrow$ Revenue generating.
   Federal or state financing is just "seed" funding
   Private Partnerships $\Rightarrow$ Revenue sharing or bartering

2. Ensuring **fairness** to all localities of a city
   $\Rightarrow$ Private companies want the best revenue generating areas

3. **Public Trust**: in government, the data, and expect actions
   Lack of transparency $\Rightarrow$ Waste of money on technologies

4. **Customization**: Every city is different.
   Private companies want to reuse their "one solution for all"

5. **Turnover**: Technology gets outdated every year or two

6. Digital **Disruption**

7. **Security and Privacy**

J. Bélissent, "Getting Clever About Smart Cities: New Opportunities Require New Business Models," Forester, Nov 2010, 33 pp.,
http://193.40.244.77/iot/wp-content/uploads/2014/02/getting_clever_about_smart_cities_new_opportunities.pdf

Public Trust

Digital Disruptions

❑ New methods ⇒ Improvements ⇒ Disruption to old methods

❑ Automation ⇒ Better efficiency ⇒ What to do with those replaced

❑ Privatization, Automation, Change ⇒ Strikes

No Privatization
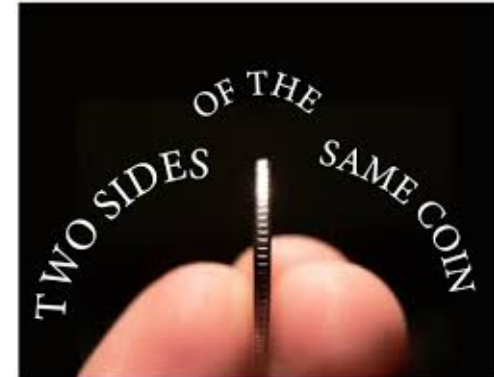
Security: Attack Surface

1. Sensors and systems

2. Operating systems (Open OS)

3. Access Network: WiFi, 3G/4G, Ethernet, Powerline, …

4. IP Network: DNS, Routers, …

5. Clouds

6. Management Platform: Web interface

7. Life Cycle Management: Booting, Pairing, Updating, …

8. Higher-layer Protocols

9. Applications

10. Human (Social engineering)

Security Statistics

❑ HP conducted a security analysis of smart (IoT) devices

  ➢ 80% had privacy concerns

  ➢ 80% had poor passwords

  ➢ 70% lacked encryption

  ➢ 60% had vulnerabilities in UI

  ➢ 60% had insecure updates

❑ Symantec Security Study:

  ➢ 22% of targeted attacks are aimed at governments and energy/utility companies

  ➢ 24% of identity breaches are targeted at government and healthcare institutions

Ref: http://fortifyprotect.com/HP_IoT_Research_Study.pdf
Symantec, "2013 Symantec Internet Security Threat Report," http://www.symantec.com/security_response/publications/threatreport.jsp?inid=us_ghp_thumbnail1_istr-2013

Smart City Insecurity

❑ **Smart Court House**: Placer county courthouse accidently summoned 1200 people to jury duty on a morning in May 2012 causing traffic jams

❑ **Smart Metro**: Bay Area Rapid Transit (BART) was shut down by a technical problem affecting 500 to 1000 passengers on 19 trains (November 2013)

❑ **Smart Electricity**: 55 Million people in Northeast USA lost electric power due to a software bug

❑ Not marking a pipeline on the map lead to a gas pipe line explosion and fire in Johnson County, Texas by workers installing electrical lines

❑ Nation states and cyber terrorists know how to make use of public data ⟹ **Smart Wars**

Ref: C. Cerrudo, "Hacking smart cities," RSA Conference 2015,
http://www.rsaconference.com/writable/presentations/file_upload/hta-t10-hacking-smart-cities_final.pdf

Areas of Research for Smart Cities

1. Broadband: DSL, FTTH, Wi-Fi, 5G, Wireless Networks
2. Mobile and Pervasive computing,
3. Middleware and Agent Technologies for embedded devices
4. Smart devices, sensors giving real-time information
5. Big-data, data mining, Machine learning, Predictive analytics
6. Web-based collaboration, Crowd sourcing
7. Cloud computing
8. Internet of Things
9. Social networking
10. Applications: Remote health, On-line education, on-line laboratories, …

Broadband: Next Generation (5G)

❑ By 2020: 1000X Traffic, 100X devices, 100X data rate, 1/5X latency, 10X battery life…

1000X Data	500B Devices	10 Gbps	Few ms End-to-End	10 yrs Life
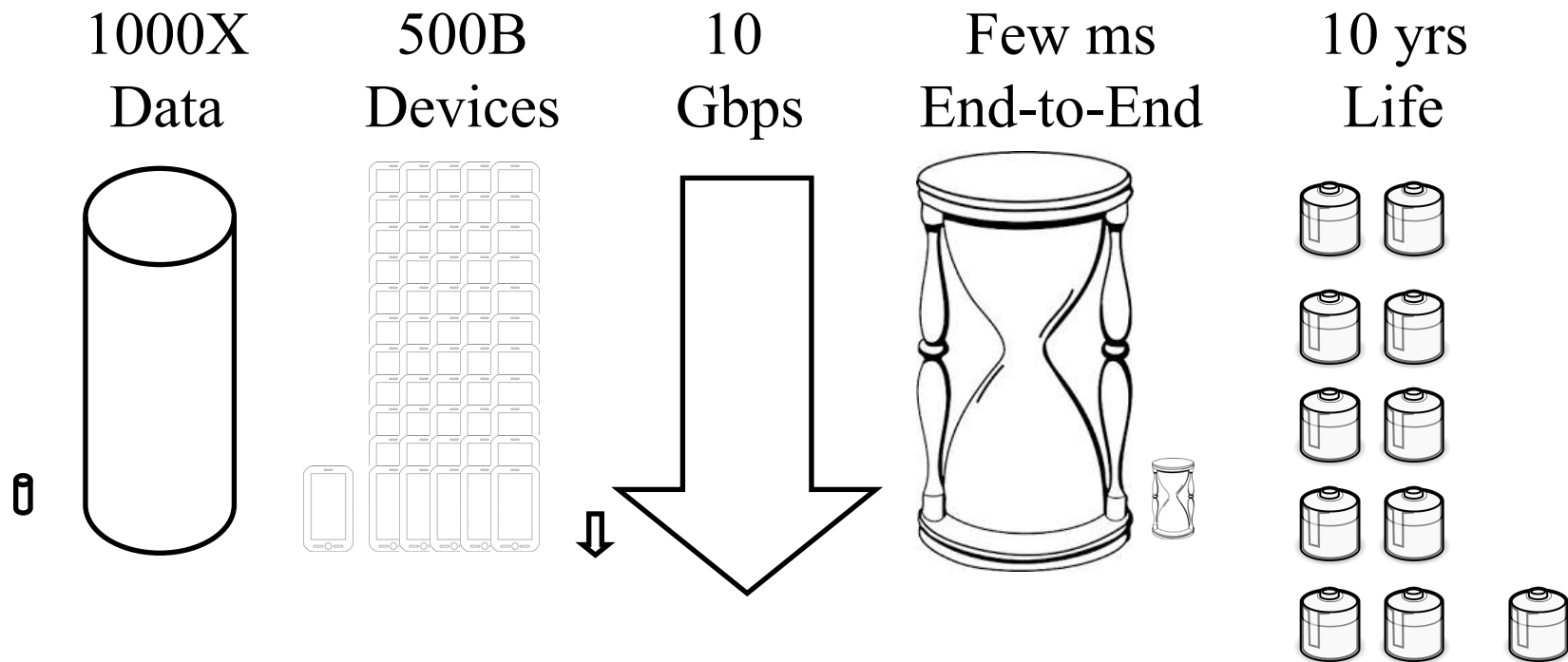
Ref: S. Hicks, "ETSI Technologies in support of smart cities," http://docbox.etsi.org/ETSI_presentations/ETSI_presentations/2015/20150601%20SIMON%20HICKS-ETSI-TECHNOLOGIES%20TO%20SUPPORT%20THE%20SMART%20CITY.ppt

Washington University in St. Louis   http://www.cse.wustl.edu/~jain/talks/smrtcit.htm   ©2015 Raj Jain

Government-Citizen Partnership

❑ Provide open data

❑ Challenge citizens to participate by design apps contests

❑ Encourage citizens to participate by **crowd sourcing**

❑ Invest in research to develop local strategies

❑ National government needs to invest in large inter-city infrastructures

City-University Partnership

❑ Presence of universities is a weak predictor of new educational startups ⇒ Universities need to connect

❑ Universities can help local government with the technology development, adoption, training, and analytics

❑ What Can we (Researchers) Do?

➤ Extend our research in to applications that are large scale

➤ Develop collaborations for integration of fields

➤ Provide proof-of-concepts

➤ Provide Open-Source development environment

Universities as Smart Testbeds

❑ Green Cup Competition for all hostels

  ➢ Users can see their consumption

  ➢ Each week top 3 winners get points

  ➢ Posting pictures to Facebook

  ➢ Wearing green t-shirts

❑ Green Labs Competition:

  ➢ Reduce energy consumption in lab

  ➢ Unplug whenever possible

  ➢ Recycle

  ➢ Label equipment

Washington University in St. Louis   http://www.cse.wustl.edu/~jain/talks/smrtcit.htm   ©2015 Raj Jain
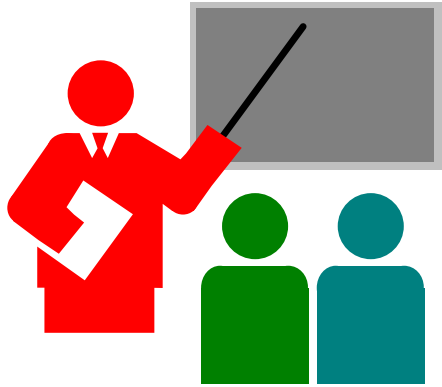
Summary

1. Smart City = Infrastructure + ICT + Sustainability + People-Private-Public Partnerships

2. Numerous challenges: Sustainable partnerships, Digital disruption, fast technology turnover, trust, …

3. Smart City is a great opportunity for computer scientists: Researchers, Industry, Developers, Engineers

4. Numerous Research Areas: Broadband (5G), Security/Privacy, big data, cloud computing

5. Universities need to get involved by providing technology, test-beds, and proof-of-concepts

References

- ANSI, "ISO 37120-2014 Preview Final V2, http://publicaa.ansi.org/sites/apdl/ANSI%20Network%20on%20Smart%20and%20 Sustainable%20Cities/ISO+37120-2014_preview_final_v2.pdf
- Gibson, D.V., Kozmetsky, G., Smilor, R.W. (eds.), "The Technopolis Phenomenon: Smart Cities, Fast Systems, Global Networks," Rowman & Littlefield, New York (1992)
- Government of India, Ministry of Urban Development, "Smart Cities: Mission Statement and Guidelines," June 2015, http://smartcities.gov.in/writereaddata/SmartCityGuidelines.pdf
- http://greencup.wustl.edu/ , http://greenlabs.wustl.edu/
- http://www.dataforcities.org/registry
- http://www.smartcities.info/6-user-needs-co-design
- http://www.theatlantic.com/technology/archive/2015/07/when-you-give-a-tree-an-email-address/398210/
- https://kannanranjiv.wordpress.com/2007/08/08/the-smart-city/
- ISO/IEC JTC 1, "Smart Cities," 2014, http://www.iso.org/iso/smart_cities_report-jtc1.pdf

References (Cont)

- Navigant Research, "Smart Cities," https://www.navigantresearch.com/research/smart-cities
- NSF, "Cultivating Smart and Connected Communities," http://nsf.gov/news/news_summ.jsp?cntn_id=136253
- Smart City Week, http://www.smartcitiesweek.com/
- S. Hicks, "ETSI Technologies in support of smart cities," http://docbox.etsi.org/ETSI_presentations/ETSI_presentations/2015/20150601%20SIMON%20HICKS-ETSI-TECHNOLOGIES%20TO%20SUPPORT%20THE%20SMART%20CITY.ppt
- T. Ezaki, "IEC SEG 1 Smart Cities WG Brief Report," http://www.y-adagio.com/public/committees/iec_tc100_ags/meetings/36/100ags602.pdf
- V. Aillaud, "Digital economy and smart métropolies : a joint future?" http://www.europmetrocci.eu/l/Portals/0/EuropmetrocciDocuments/london%2030-31%20october%202013/PARIS%20Smart-cities%20Valerie%20AILLAUD.ppt
- WCCD, "WCCD ISO 37120 Certification," http://www.dataforcities.org/iso

Standards for Smart Cities

1. **ISO 37120:** Sustainable development & resilience of communities - Indicators for city services & quality of life

2. **ISO/TR 37150:** Smart community infrastructures - Review of existing activities relevant to metrics

3. **ISO 37101:** Sustainable development & resilience of communities - Management systems - General principles & requirements

4. **ISO 37102:** Sustainable development & resilience of communities - Vocabulary

5. **ISO/TR 37121:** Inventory & review of existing indicators on sustainable development & resilience in cities

6. **ISO/TS 37151:** Smart community infrastructure metrics - General principles & requirements

7. **ISO/TR 37152:** Smart community infrastructures -- Common framework for development & operation

Standards for Smart Cities (Cont)

❑ IEC/SEG 1: Systems Evaluation Group on Smart Cities

❑ ITU-T SG5 FG-SSC: Focus group on smart sustainable cities

  ➢ SSC-0100-Rev 2: Smart Sustainable cities – Analysis of Definitions

  ➢ SSC-0110: Technical Report on Standardization Activities and Gaps for SSC and suggestion to SG5, ITU-T

  ➢ SSC 162: Key performance indicators (KPIs) definitions for smart sustainable cities

❑ CEN-CENELEC-ETSI SSCC-CG: Smart and Sustainable Cities and Communities Coordination Group

❑ **JTC 1**: Study Group on Smart Cities

❑ ISO TC 59:

  ➢ ISO 15686: Buildings and constructed assets – Service life planning

  ➢ ISO 16739: Industry foundation classes (IFC) for data sharing in the construction and facility management industries

Ref: T. Ezaki, "IEC SEG 1 Smart Cities WG Brief Report," http://www.y-adagio.com/public/committees/iec_tc100_ags/meetings/36/100ags602.pdf

ITU-T Focus Group on Smart Sustainable Cities, https://www.itu.int/dms_pub/itu-t/oth/0b/04/T0B0400004F2C01PDFE.pdf

Standards for Smart Cities (Cont)

- ❑ ISO TC 204: Intelligent transport systems
- ❑ ISO TC 163 and ISO TC 205:
  - ➢ ISO 16346: Energy performance of buildings – Assessment of overall energy performance
  - ➢ ISO 16343: Energy performance of buildings – Methods for expressing energy performance and for energy certification of buildings
  - ➢ ISO 12655: Energy performance of buildings – Presentation of measured energy use of buildings
  - ➢ ISO/TR 16344:2012, Energy performance of buildings – Common terms, definitions and symbols for the overall energy performance rating and certification
  - ➢ ISO 13153-2012: Framework of the design process for energy saving single-family residential and small commercial buildings

Standards for Smart Cities (Cont)

- ❑ ISO TC 223:
  - ➢ ISO 22316: Societal Security – Organizational resilience – Principles and guideline
  - ➢ ISO 22301-2012: Societal security – Business continuity management systems – Requirements
  - ➢ ISO 22313-212: Societal security – Business continuity management systems – Guidance
  - ➢ ISO 22398: Societal security – Guidelines for exercises
  - ➢ ISO 22320-2011: Societal Security – Emergency management – Requirements for Incident response
  - ➢ ISO 22324: Societal security – emergency management – color coded alert
- ❑ ISO TC 241:
  - ➢ ISO 39001-2012: Road traffic safety (RTS) management systems – Requirements with guidance for use

Standards for Smart Cities (Cont)

- ❑ ISO TC 257:
  - ➢ ISO 50001-2011: Energy management systems – Requirements with guidance for use
  - ➢ ISO/CD 17741 General technical rules for measurement, calculation and verification of energy savings of projects
  - ➢ ISO/DIS 17742 General Calculation Measures on Energy Efficiency and Savings for Countries, Regions and Cities
  - ➢ ISO/DIS 17743 Energy savings -- Definition of a metrological framework applicable to calculation and reporting on energy savings
  - ➢ ISO/CD 17747 Determination of energy savings in organizations
  - ➢ ISO/DIS 50015 Energy management systems -Measurement and Verification of Organizational Energy Performance -- General Principles and Guidance
- ❑ **TC 268**: Sustainable development in communities
- ❑ **TC 268/SC 1**: Smart community infrastructures

Standards for Smart Cities (Cont)

❑ ISO/TC TMB: Technical Management Board
  ➢ ISO 20121-2012: Event sustainability management systems – Requirements with guidance for use
  ➢ ISO 26000-2010: Guidance on social responsibility
  ➢ IEEE: IEEE 2030.1, 2030.2 smart grid interoperability, 1901, 1901.2 smart meter
❑ NIST: Smart Grid Interoperability
❑ German Commission for Electrical, Electronic & Information Technologies of DIN and VDE (DKE):
  ➢ Roadmap and recommendations for action in Germany
❑ British Standards Institute (BSI):
  ➢ BSI PAS 180: Smart Cities – Vocabulary
  ➢ BSI PAS 181: Smart City Framework – Guide to establishing strategies for smart cities and communities

Standards for Smart Cities (Cont)

❑ BSI PAS 182: Smart City Concept Model
  ➢ BSI PD 8100: Smart City Overview – A guide for city managers
  ➢ BSI PD 8101: Smart Cities – Guide to the role of the planning and development process
  ➢ BS 8904 Guidance for community sustainable development
  ➢ BS 11000 Collaborative Relationship Management
❑ China National IT Standardization (NITS) TC:
  ➢ Investigation Report on Status of Smart Cities and Standard Needs in China
  ➢ Draft Research Report on China Standard System on Smart Cities
  ➢ Implementation Guidance for Smart Cities (a book)

Acronyms

- 4G   Fourth Generation
- 5G   Fift Generation
- ANSI   American National Standards Institute
- BJP   Bhartiya Janata Party
- BS   British Standard
- BSI   British Standards Institute
- CD   Committee Draft
- CEN   European Committee for Standardization
- CENELEC   European Committee for Electro technical Standardization
- CG   Coordination Group
- CS   Computer Society (IEEE)
- DIN   Deutsches Institut für Normung
  (German Institute for Standardization)
- DIS   Draft International Standard
- DSL   Digital Subscriber Line
- DTS   Draft Technical Specification

Acronyms (Cont)

- ETSI   European Telecommunications Union
- FG-SSC   Focus group on smart sustainable cities
- FTTH   Fiber to the home
- FTTx   Fiber to the X
- GDP   Gross Domestic Production
- GIS   Geographical Information Systems
- GPS   Global Positioning System
- ICT   Information and Communication Technology
- ID   Identification
- IEC   International Electrotechnical Commission
- IEC/SEG   IEC Systems Evaluation Group
- IEEE   Institute of Electrical and Electronic Engineers
- IFC   Industry Foundation Classes
- IMS   IP Multimedia System
- IoT   Internet of Things

Acronyms (Cont)

- IP   Internet Protocols
- IQ   Intelegence Quotient
- ISBN   International Standard Book Number
- ISO   International Standards Organization
- IT   Information Technology
- ITU-T   International Telecommunications Union - Telecommunication Standardization Sector
- JTC   Joint Technical Committee
- KPI   Key Performance Indicator
- LTE   Long-Term Evolution
- MO   Missouri
- NIST   National Institute of Technology
- NSF   National Science Foundation
- OS   Operating System
- PAS   Publicly Available Specification
- PD   Published Document

Acronyms (Cont)

- RFID   Radio Frequency Identifier
- RoW   Rest of the World
- RTS   Road traffic safety
- SC   Smart community
- SEG   System Evaluation Group
- SG5   Study Group 5
- SOA   Service oriented Architecture
- SSC   Smart and Sustainable Cities and
- SSCC-CG   Smart and Sustainable Cities and Communities Coordination Group
- SW   Software
- TC   Technical Committee
- TMB   Technical Management Board
- TR   Technical Report
- TS   Technical Specification
- TV   Television

Acronyms (Cont)

- US   United States
- USA   United States of America
- VDE   Association for Electrical, Electronic & Information Technologies
- WCCD   World Council on City Data
- WG   Working Group
- WiFi   Wireless Fidelity