Standards Prospective: Big Data and Internet of Things—Promoting Interoperability via Open Standards and Semantic Technologies

A presentation at the

ITU Workshop on Internet of Things Applications for Development
April 25, 2017
Port of Spain, TRINIDAD and TOBAGO

Rob Frieden, Pioneers Chair and Professor of Telecommunications and Law
Penn State University
rmf5@psu.edu
Web site : http://www.personal.psu.edu/faculty/r/m/rmf5/
Blog site: http://telefrieden.blogspot.com/

The Main Points

The Internet of Things potentially constitutes a consumer welfare and operator revenue enhancing proposition. Alas, the "Devil is in the Details."

Many more stakeholders, constituencies and candidate forums involved than for traditional telecommunications and Internet interoperability issues, e.g., banking, health care, urban development, transportation, etc.

Incumbent planning, policy making and regulatory regimes confront a vastly increased agenda, including matters for which they may lack jurisdiction.

With such high stakes, incumbents and insurgents alike have incentives to establish proprietary rather than open standards and interfaces; real potential for near monopoly intermediaries/platform operators, or "balkanization."

Many new challenges involving trust, security and privacy add to the burden and scope of governmental concerns previously emphasizing competition policy, standard setting, spectrum management and licensing.

Immediate challenges: extend successful telecommunications and Internet open standards, interoperability and permissionless innovations.

How Did We Get Here?
The First 4 Phases in Internet Development

1) Incubation--government as anchor tenant and underwriter, first through the United States Defense Department and later through the United States National Science Foundation along with research institutes throughout the world (1980s-1995);

2) Privatization--governments eliminate financial subsidies obligating contractors to assess whether and how to operate commercially (1995-1998);

3) Commercialization—private networks proliferate as do ventures creating software applications and content that traverse the Internet. The "dotcom boom" triggers excessive investment and overcapacity (1998-2001); and

4) Diversification—after the dotcom bust and market re-entrenchment, Internet survivors and market entrants expand the array of available services and ISPs offer diversified terms, conditions and rates, including price and quality of service discrimination needed by "mission critical" traffic having high bandwidth requirements, e.g., full motion video content. ISPs and even content providers can use deep packet inspection to identify traffic for "better than best efforts" routing and other forms of prioritization at one extreme and blockage/throttling at the other.

An Evolving 5th Phase

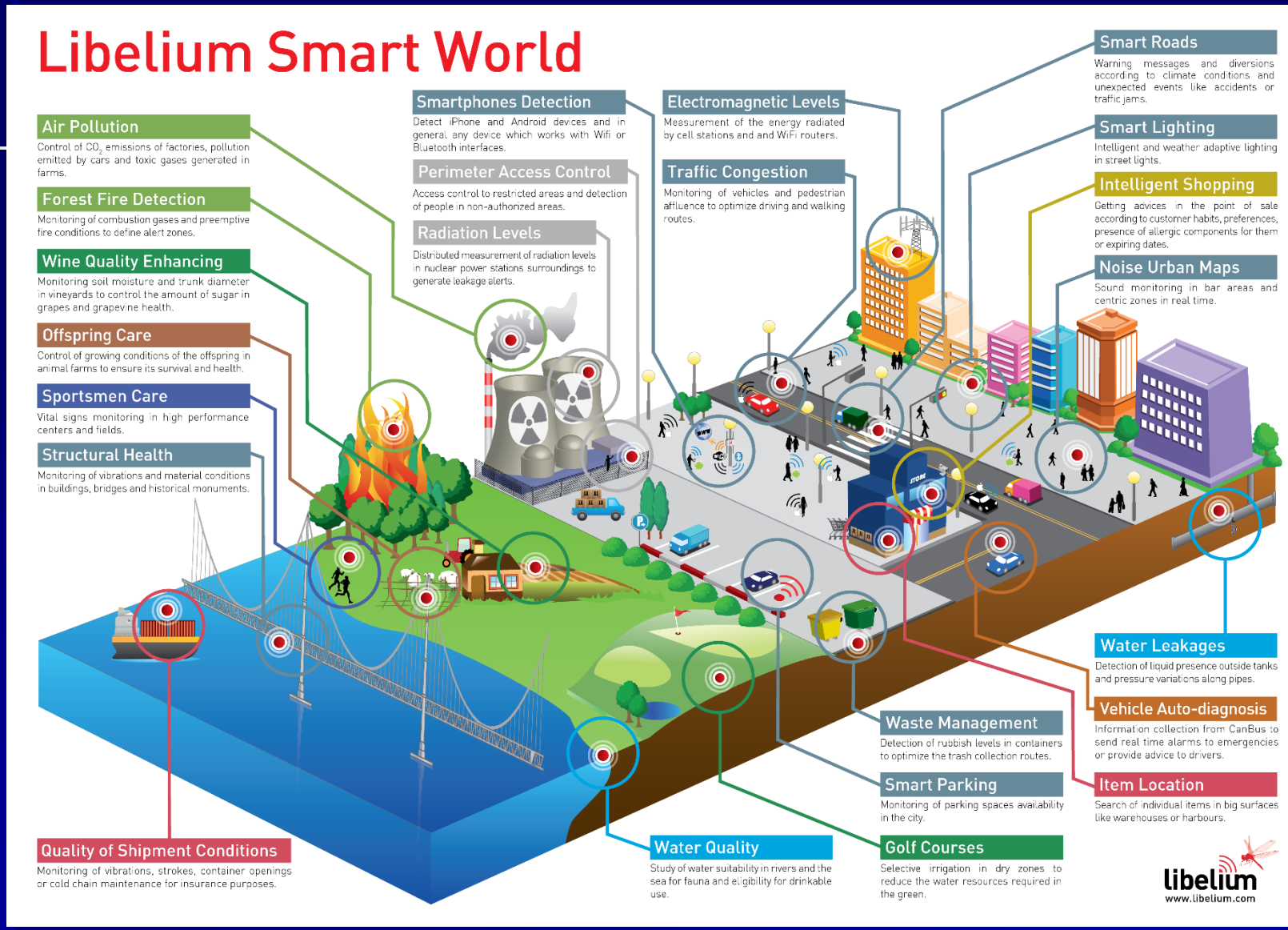
- Widespread diffusion of broadband infrastructure and increasing consumer demand for anytime, anywhere access to IPTV content, plus Internet of Things reaches critical mass.

- Even as the Internet bit transmission marketplace concentrates, the number and type of applications expands significantly. More machines communicate with each other than P2P and P2M.

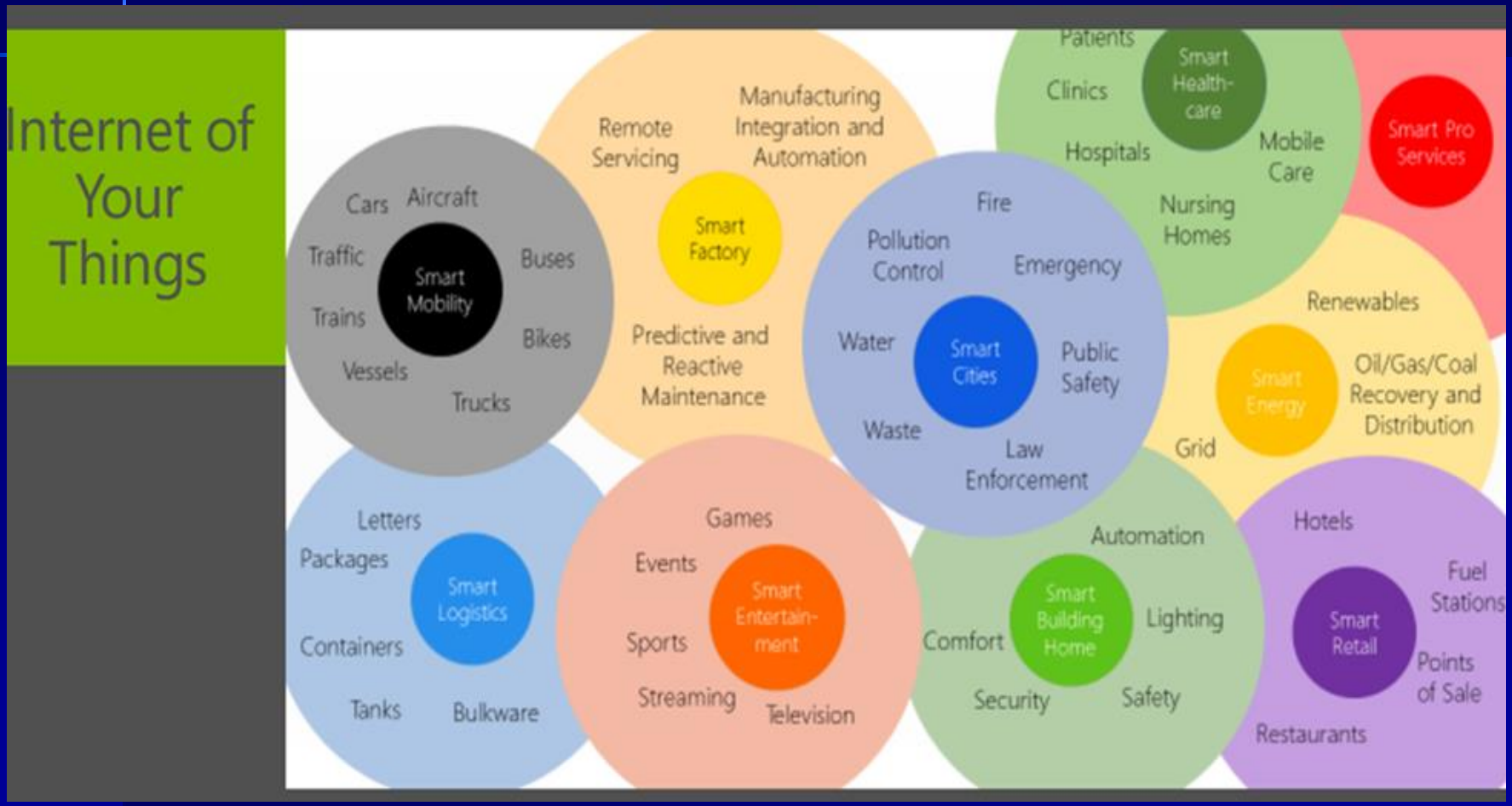
- Increasing pressure on a "one size fits all" Internet with growing incentives for private networking possibly using proprietary standards.

- Can the TCP/IP baseline accommodate diverse new things? Migration to IVP6 a successful model, but not all IoT applications will operate within an Internet topology.

Diversifying Applications and Stakeholders

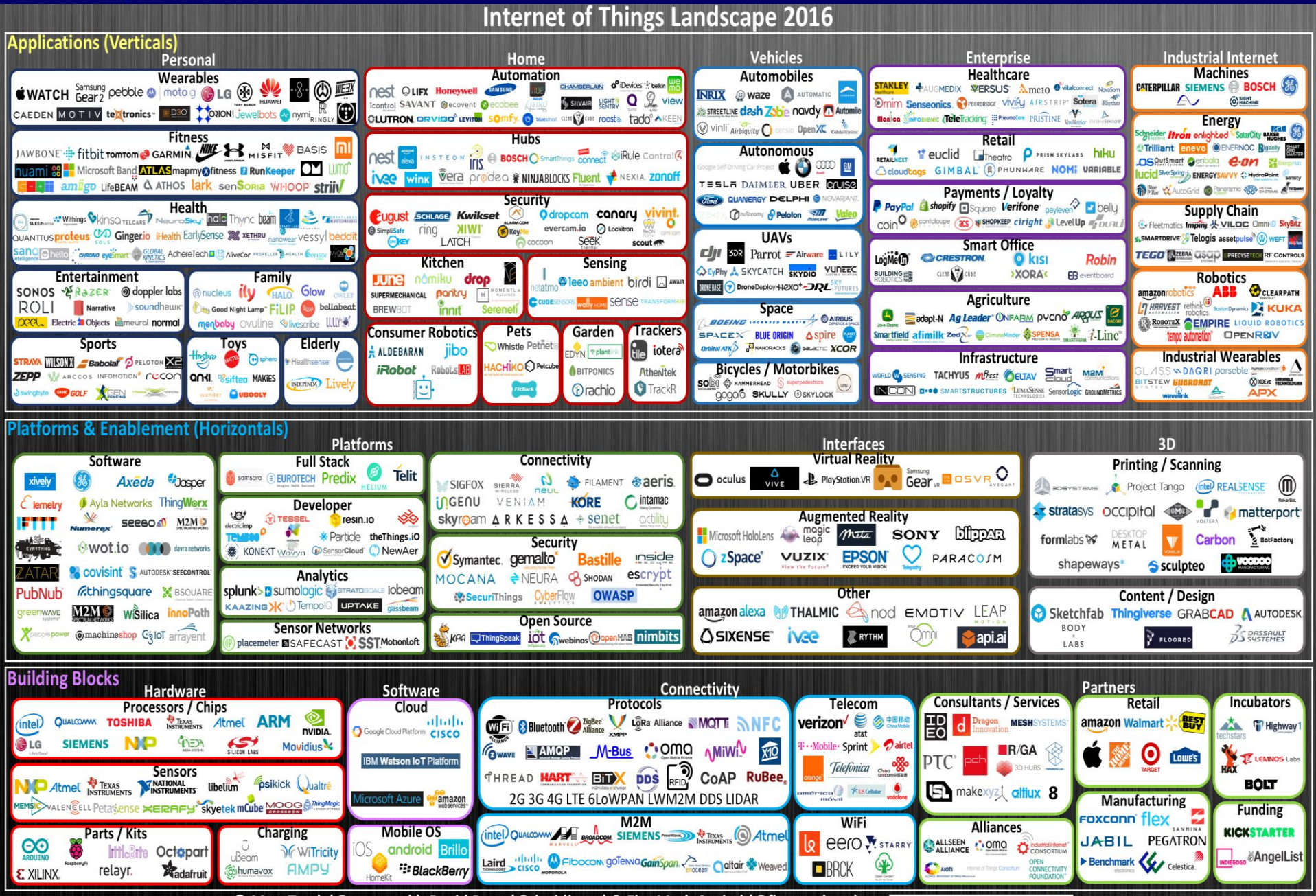


Diversifying Applications and Stakeholders (cont.)



Source: E. Stephens, Adopting the IoT Paradigm: Challenges and Opportunities (18 Jan. 2016); available at: https://www.itu.int/en/ITU-T/Workshops-and-Seminars/iot/20160118/Documents/Presentations/Session1/Session1-4-Erick%20Stephens-18Jan16.pdf.

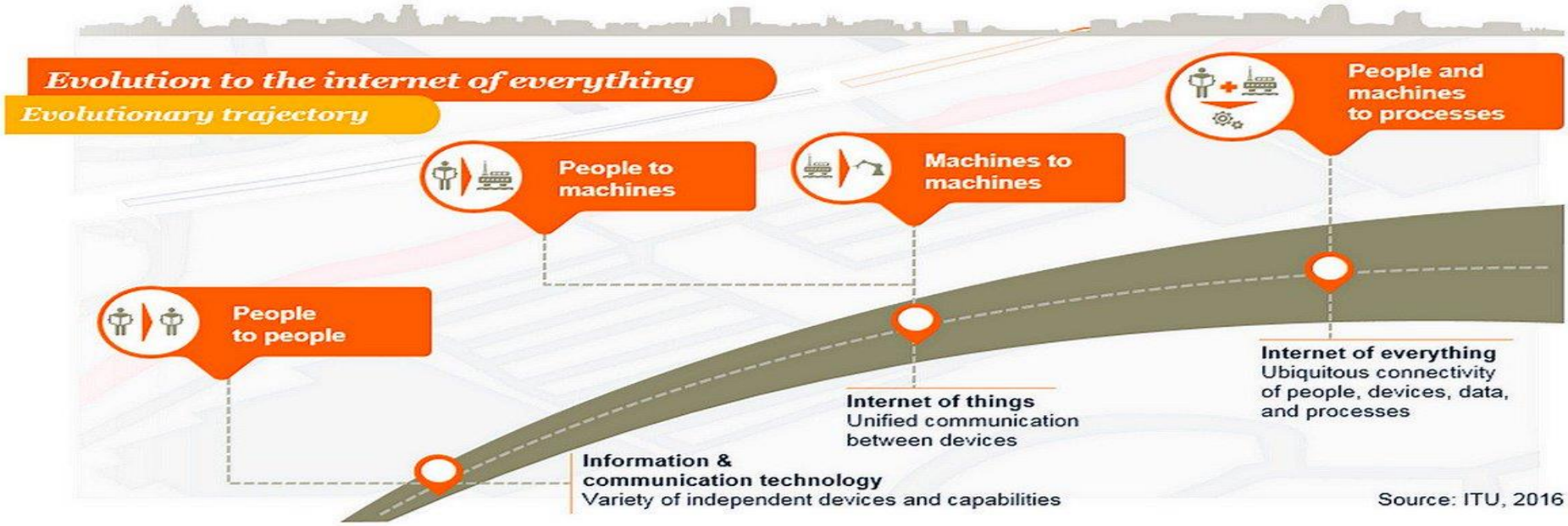
Diversifying Applications and Stakeholders (cont.)

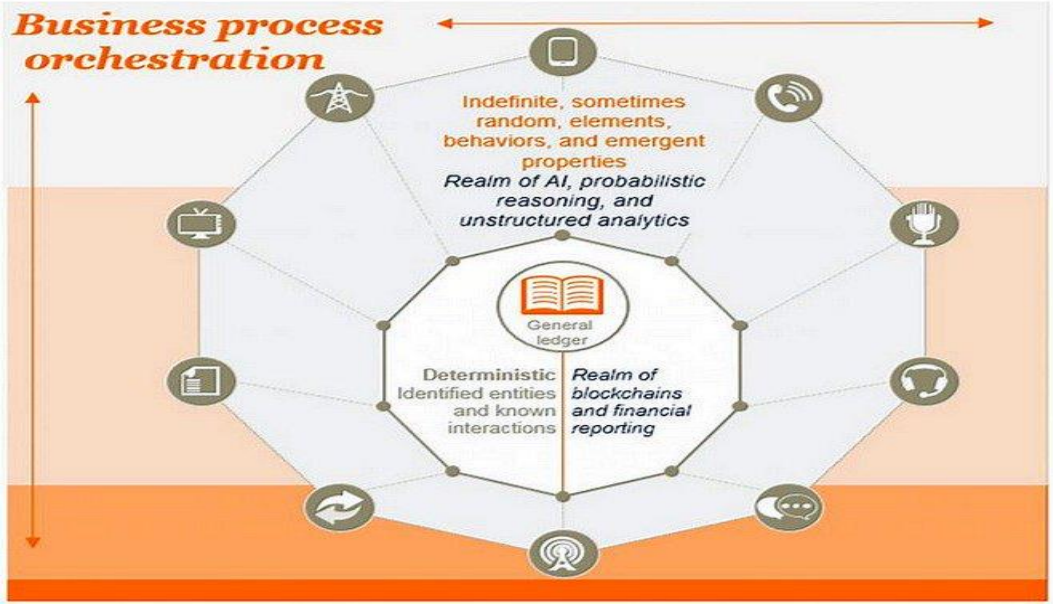


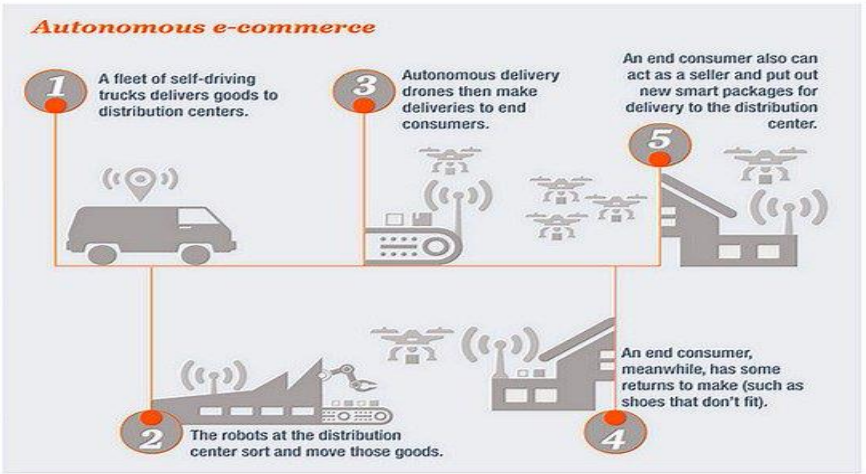
Expanded Diversity, or Balkanization?

- The optimist anticipates an Internet ecosystem ever faster, better, smarter, cheaper and more convenient.
- A golden age where machines gain insight, spot trends and enhance their agility to achieve goals; algorithms can anticipate and serve the wants, needs and desires of consumers, citizens and stakeholders.
- The pessimist consider an analogy to Yugoslavia:

If Only It Was This Easy







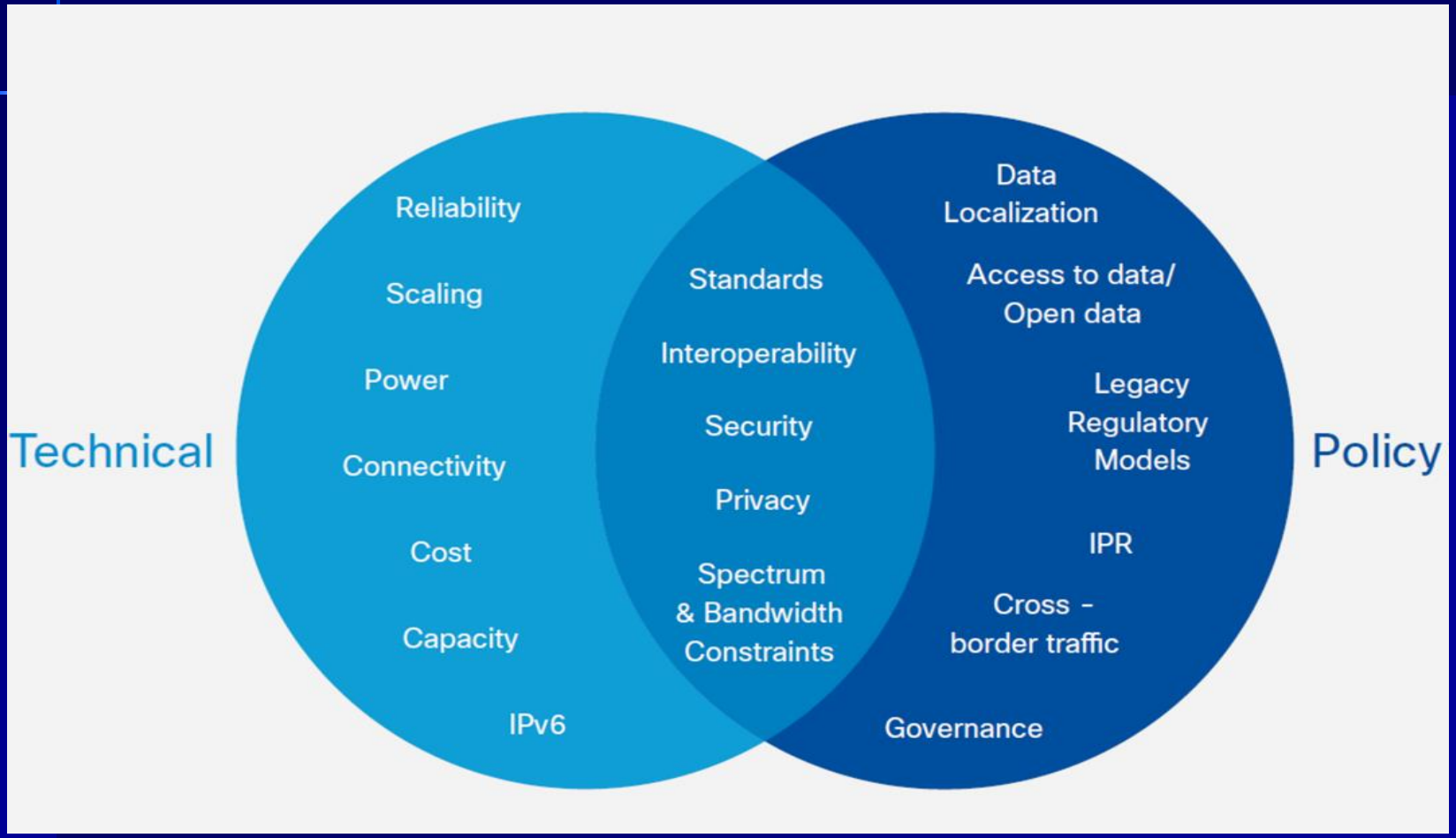
If Only Legacy Protocol Stacks Solved All Issues

OSI (Open Source Interconnection) 7 Layer Model

Layer	Application/Example		Central Device/ Protocols			DOD4 Model
Application (7) Serves as the window for users and application processes to access the network services.	**End User layer** Program that opens what was sent or creates what is to be sent Resource sharing • Remote file access • Remote printer access • Directory services • Network management		**User Applications** SMTP	GATEWAY		Process
Presentation (6) Formats the data to be presented to the Application layer. It can be viewed as the "Translator" for the network.	**Syntax layer** encrypt & decrypt (if needed) Character code translation • Data conversion • Data compression • Data encryption • **Character Set Translation**		JPEG/ASCII EBDIC/TIFF/GIF PICT			
Session (5) Allows session establishment between processes running on different stations.	**Synch & send to ports** (logical ports) Session establishment, maintenance and termination • Session support - perform security, name recognition, logging, etc.		**Logical Ports** RPC/SQL/NFS NetBIOS names			
Transport (4) Ensures that messages are delivered error-free, in sequence, and with no losses or duplications.	**TCP** Host to Host, Flow Control Message segmentation • Message acknowledgement • Message traffic control • Session multiplexing	PACKET FILTERING	TCP/SPX/UDP			Host to Host
Network (3) Controls the operations of the subnet, deciding which physical path the data takes.	**Packets** ("letter", contains IP address) Routing • Subnet traffic control • Frame fragmentation • Logical-physical address mapping • Subnet usage accounting		**Routers** IP/IPX/ICMP		Can be used on all layers	Internet
Data Link (2) Provides error-free transfer of data frames from one node to another over the Physical layer.	**Frames** ("envelopes", contains MAC address) [NIC card — Switch — NIC card] (end to end) Establishes & terminates the logical link between nodes • Frame traffic control • Frame sequencing • Frame acknowledgment • Frame delimiting • Frame error checking • Media access control		**Switch Bridge WAP** PPP/SLIP	Land Based Layers		Network
Physical (1) Concerned with the transmission and reception of the unstructured raw bit stream over the physical medium.	**Physical structure** Cables, hubs, etc. Data Encoding • Physical medium attachment • Transmission technique - Baseband or Broadband • Physical medium transmission Bits & Volts		**Hub**			

A Pressing Need for More Cooperation

Expanding categories of stakeholders and conflicting incentives risk delaying and reducing progress



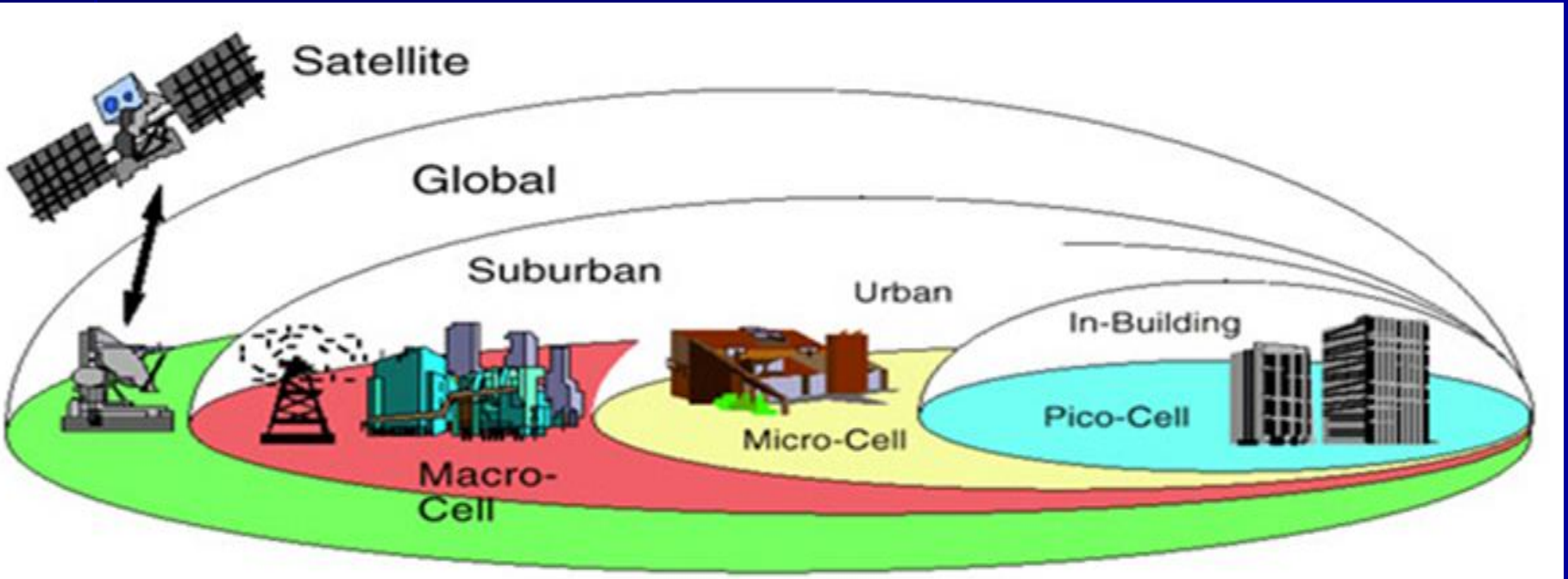
Source: R. Pepper & J. Garrity, The Internet of Everything: How the Internet Unleashes the Benefits of Big Data (2014); available at https://www.itu.int/en/action/broadband/Documents/Harnessing-IoT-Global-Development.pdf.

Challenges to Legacy Cooperation Models

Inter-governmental forums and voluntary NGOs have achieved largely positive consensus standards, including spectrum allocations.

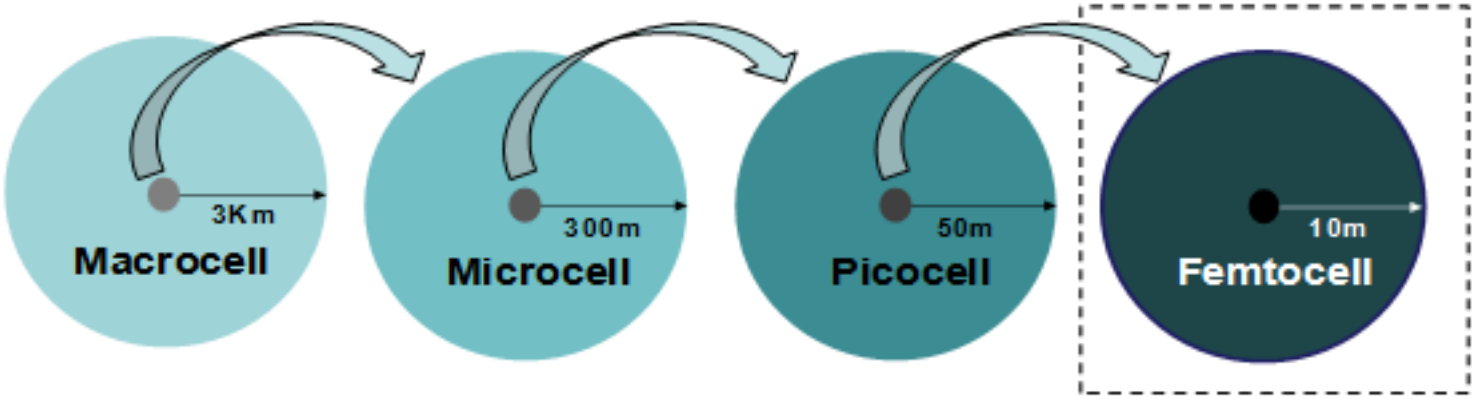
Can this model extend to diverse current and future Internet-mediated transactions, such as fintech, drones, autonomous vehicles, intelligent roads and cities, telehealth, e-government, etc.?

On the positive side, private and public stakeholders have largely agreed on flexible and sustainable technical protocols for both the Internet and wireless applications. Cloud computing, big data and IoT need ubiquitous and overlapping radio footprints of various contours.



Legacy Cooperation Models (cont.)

Fig. 1. Types of 'small cells' and typical coverage range compared to macrocells



Source: MarketsandMarkets

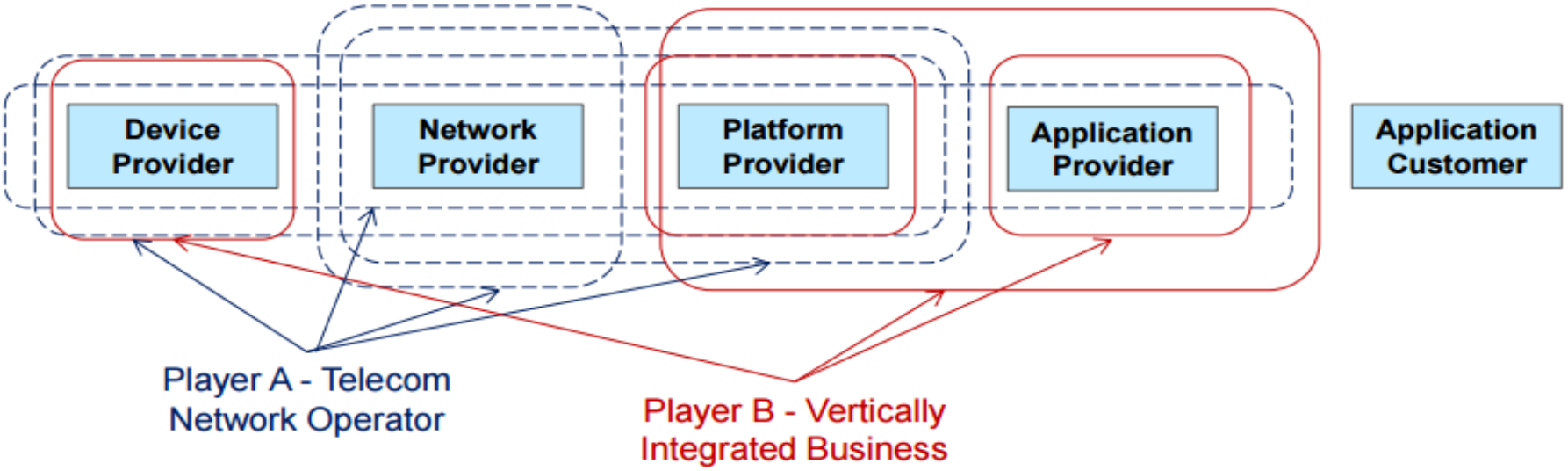
Internet of Things (2/3)

- ITU-T work on ubiquitous sensor networks (USN)

New Players and Fragmenting Roles

- The IoT/Cloud Computing/Big Data Analytics ecosystem generates greater complexity and growing incentives not to cooperate.

- Variety of roles in the IoT ecosystem from the perspective of telecom service & network operators

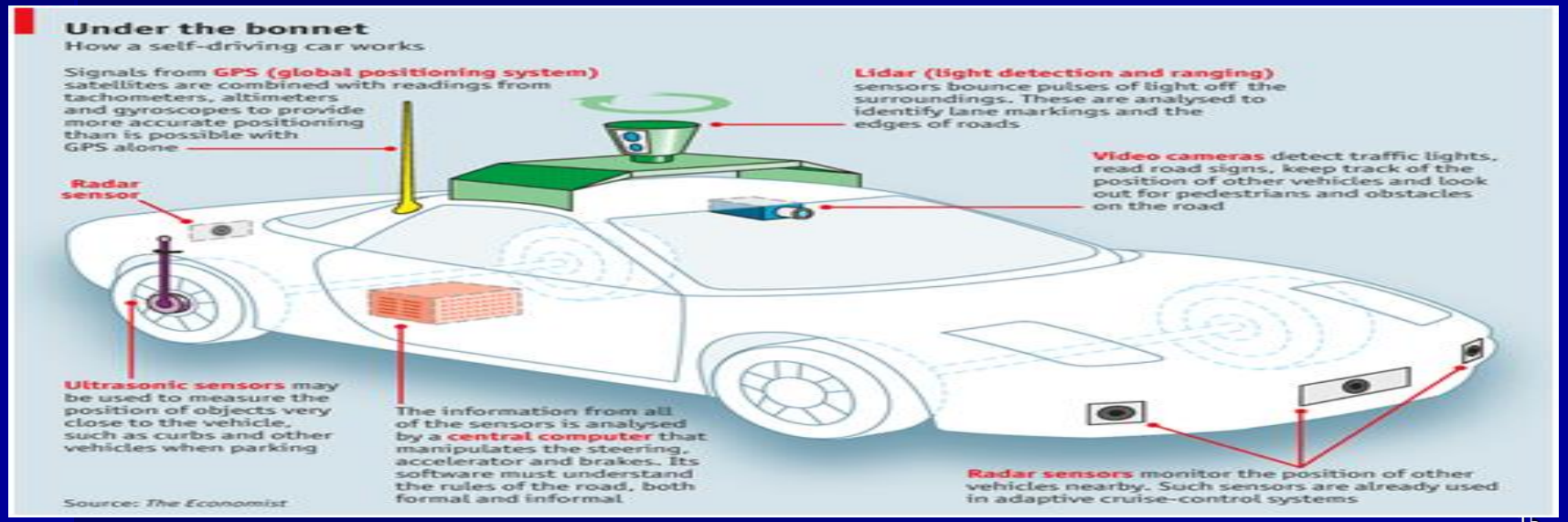


- Telecom network operators as Players A
  - Network & Platform Providers in access and control of IoT, and device management
- Vertically integrated businesses as Players B
  - Provision of reliable and secure IoT devices for communication, sensory and actuation functions in the delivery of data and content
  - Provision of IoT applications to application customers

Source: A. Chia, Adopting the IoT Paradigm: Challenges and Opportunities for Regulators (18 Jan. 2016); available at: https://www.itu.int/en/ITU-T/Workshops-and-Seminars/iot/20160118/Documents/Presentations/Session1/Session1-2-AileenChia-18-01-2016.pdf.

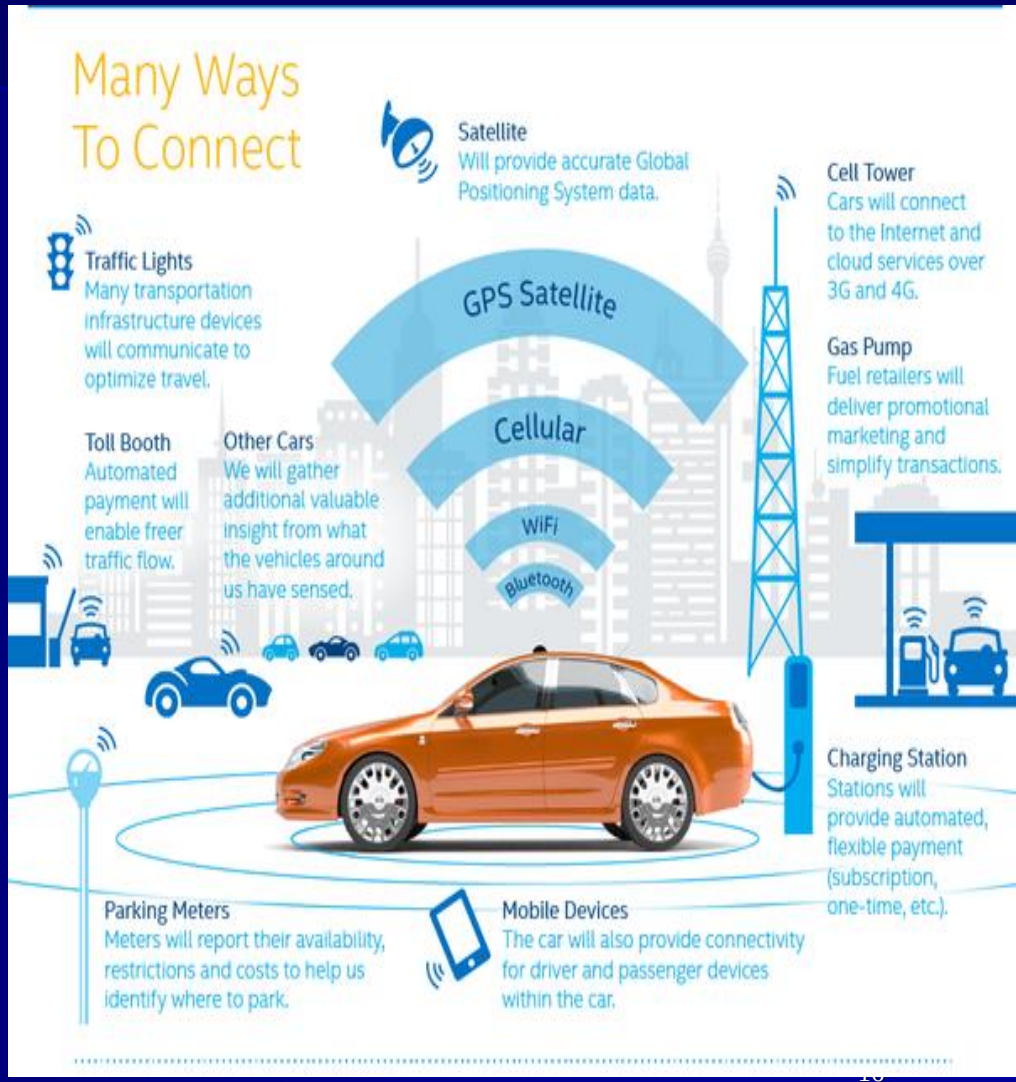
Scenario 1: Stand Alone IoT

In some scenarios, interoperability is not required, because sensing performed on a stand alone basis. On board collision detection is self-contained.



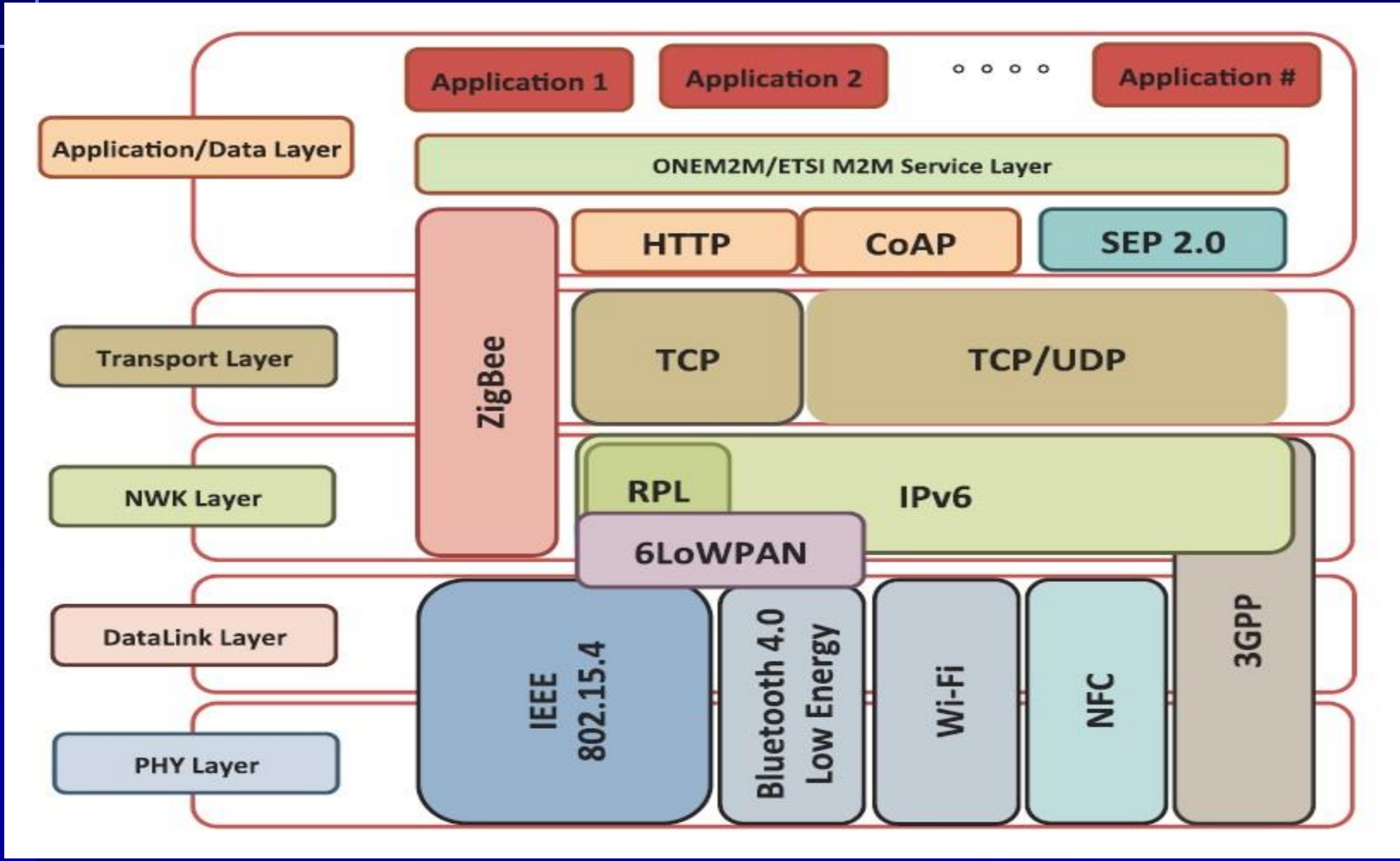
Scenario 2: Integrated IoT

Greater functionality and utility require interoperability and consensus on interfaces, standards, protocols, etc.

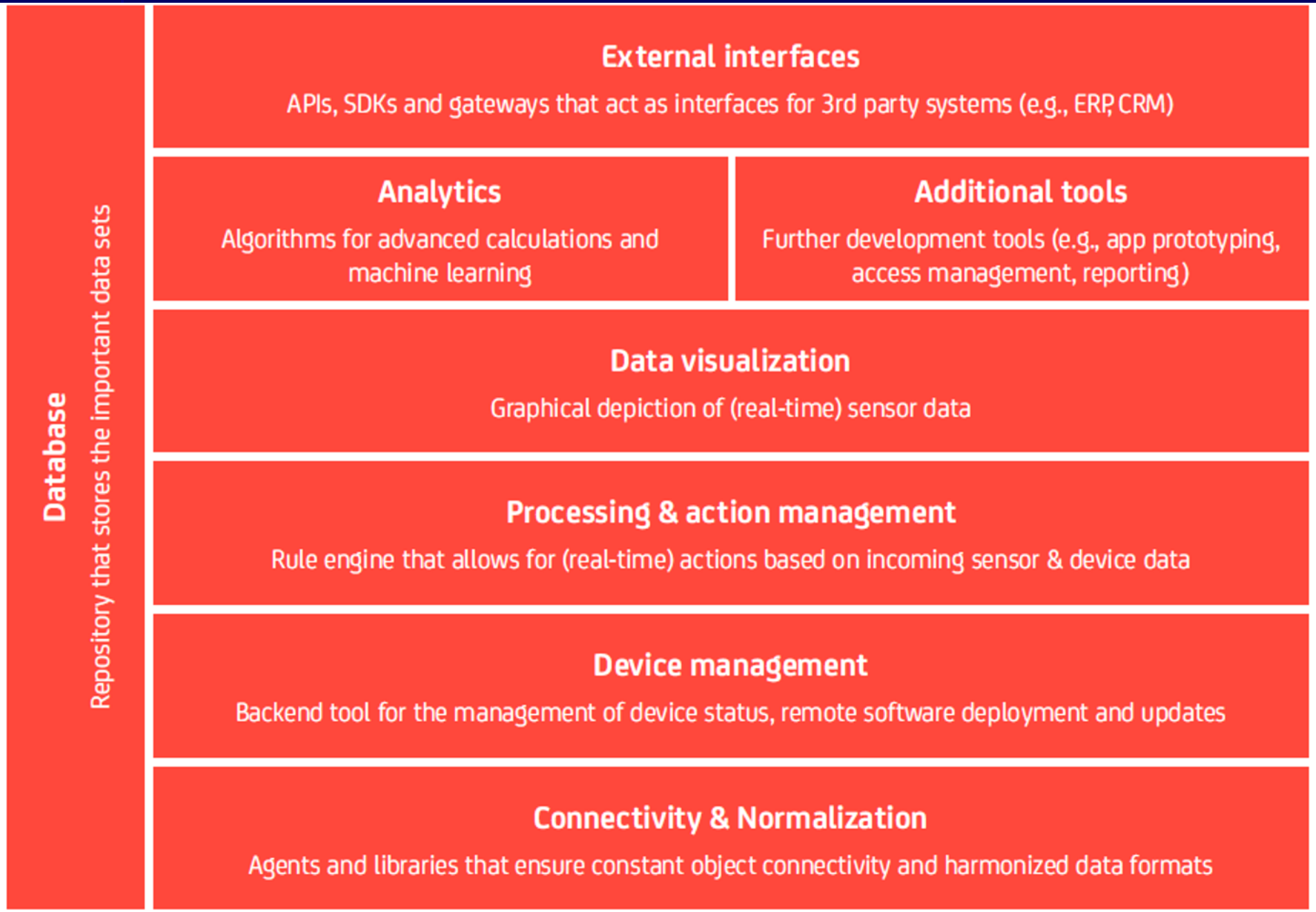


Scenario 3: Fully Interconnected IoT

Maximum functionality and utility require fully interoperability with versatile interfaces, protocols, etc.



Scenario 3: Fully Interconnected IoT



Preliminary Conclusions

The expansive Internet of Things ecosystem has many deep-pocketed ventures and governments with a history of prevailing in "winner take all" standard setting. That's why we have different standards for automobile steering wheels, broadcast television, mobile radio, Internet messaging, and just now audio plugs (Apple vs. rest of the world).

The Internet achieved great and speedy success, because openness, standard protocols and permission less innovation were imbedded at the outset. Extension of this model unlikely unless existing Internet protocols can stretch to satisfy a much larger set of stakeholders.

Expect early movers, (both incumbents and insurgents) to adopt a winner take all posture at least initially; vastly lucrative rewards accrue to the preferred platform operator able to exploit positive networking effects, patent exclusivity and the bandwagon effect.

Governments not totally free of incentives to favor national heroes and promote industrial policy. Nevertheless, they may have to lead inter-governmental forums if voluntary, non-governmental forums fail.