The Long and Wireless Road

Norman E. Shaw
Director, IEEE-Standards Association

Paul Gaugin - 1897

*D'où Venons Nous / Que Sommes Nous /
Où Allons Nous*

*Where Do We Come From? What
Are We? Where Are We Going?*

D'ou Venons Nous?

Where do we come from?

…or, a short walk down wireless memory lane.

Where Do We Come From?

- **Architecture**
- **Data**
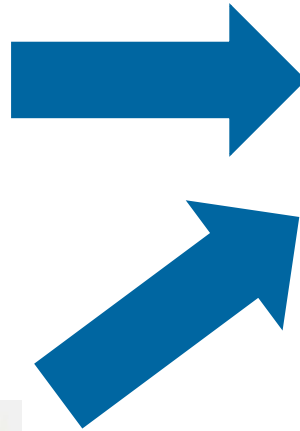- **Applications**

0G – Radio Telephones
1G – AMPS IS-91 (also DataTAC, Mobitex, NMT, etc.)
2G – GSM (also D-AMPS, TDMA, iDEN, etc.)
3G – UMTS (also CDMA2000, WiDEN, etc.)
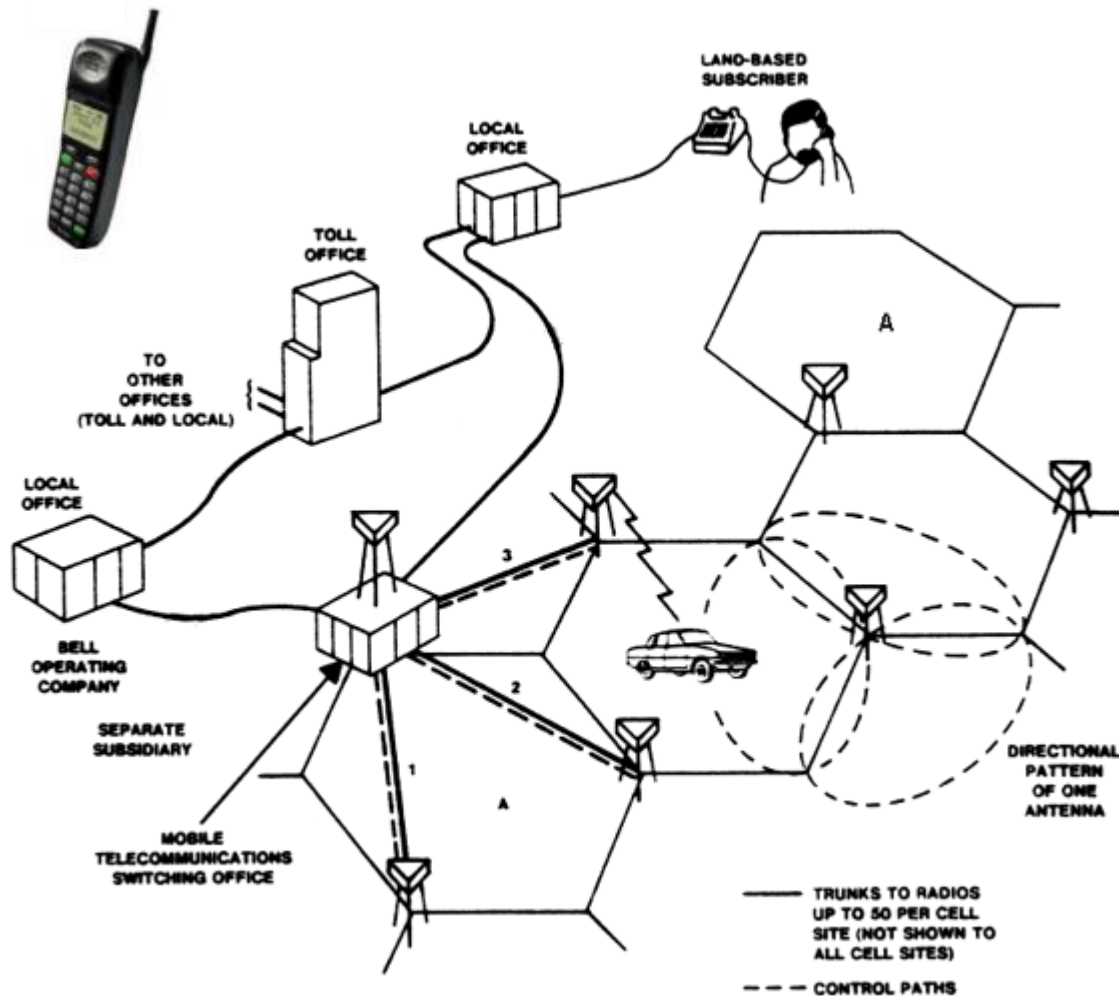**4G** – EUTRA (also WiMAX, etc.)

0G – Radio Telephones (1980's)

OMG – I can call home with my radio!!!

1G – Advanced Mobile Phone Service "AMPS" Network Diagram (1980's)
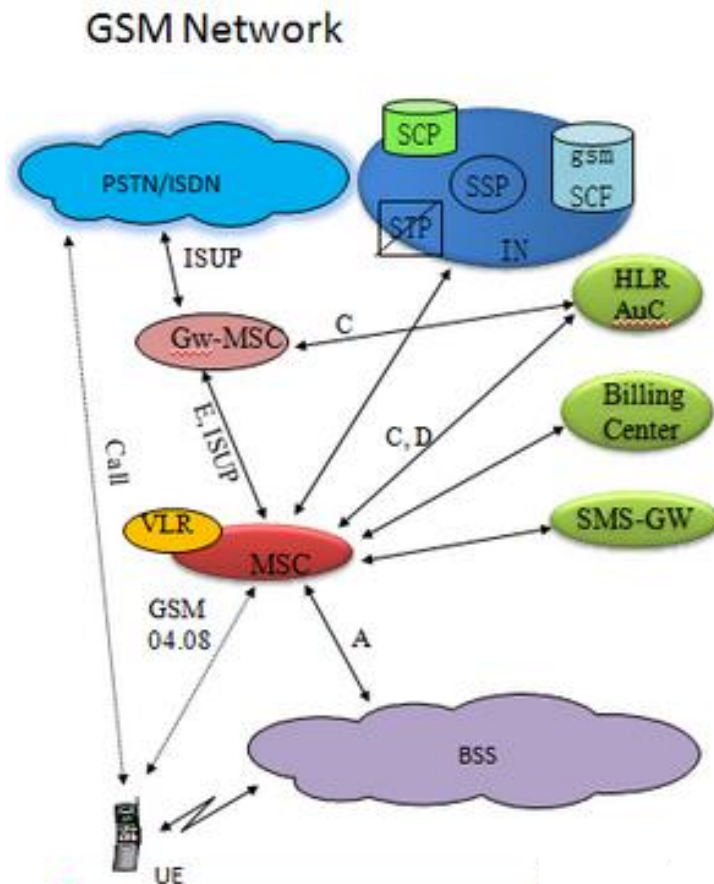

Analog

- Killer App = Voice

- Data Service over <u>CDPD</u>
  - 1 DS0/Sector
  - Through DACCS
  - Lost 1 voice channel

- Usually a T1/Sector
  - 1 control channel
  - 23 voice channels

Does anyone remember what a "T-Coder" is?

2G – Global System for Mobile (GSM) (also D-AMPS, <u>TDMA</u>, iDEN, etc.) (1990's)
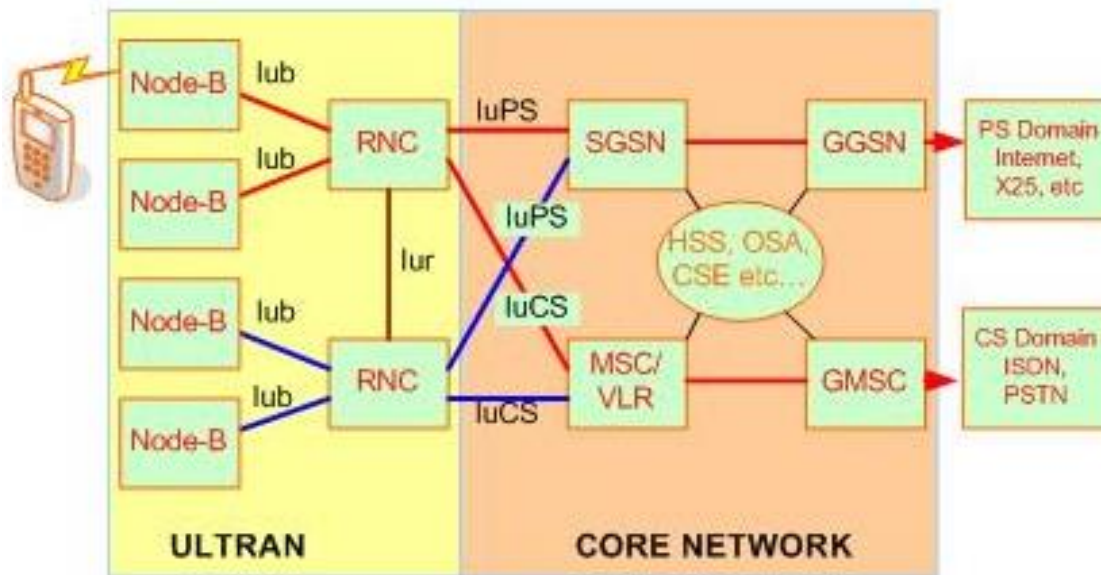

GSM Network

Digital Voice

- Killer App = SMS

- Data Service over WAP
  - **Walled Garden**
  - GPRS - SGSN, GGSN

- Still a data-over-voice Network…voice-centric

- SS7…SS7…SS7

- Still T1 sector backhaul

WAP is crap and WOS is worse…

3G – Universal Mobile (2000's) Telecommunications System (UMTS)

Digital Voice

- Killer App = "www" and "CrackBerry"

- Wideband-CDMA (W-CDMA)

- Heterogeneous data/voice network

- Still T1 sector backhaul

Gateways and Nodes…

...and then something BIG happened!

1999 - Blackberry

2007 - iPhone
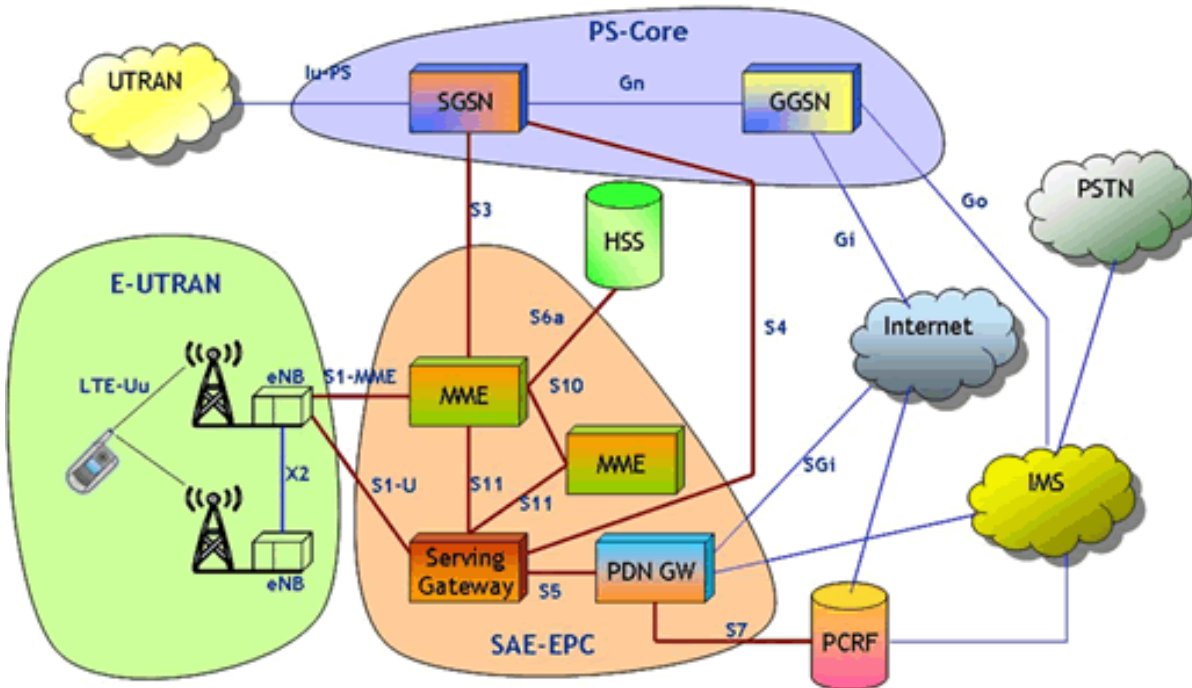
- The introduction of the "Smartphone" fundamentally changed the direction and motivation behind wireless communications.

4G – Long Term Evolution (LTE) (2010's)

Data-centric Network

- Killer App = Facebook

- *Where is the clear voice path???*

- Broadband backhaul

WAP is crap and WOS is worse…

Que Sommes Nous?

What are we?

…how does our work fit in the big picture?

What Are We?

- Cellular telephony *began* as an alternative access for mobile voice communications

  - Based on Radio Communication Fundamentals (and frequency reuse)

- Currently, this technology is a **primary access technology** to "content"

Ou Allons Nous?

Where are we going?

…What is 5G and what do they mean by IoT?

…Just how "Connected" are the vehicles going to be?

…Are we going down the "dumb-pipe" path?

5G – …and so it goes

- Multiple Radio Access Technologies (RATs)
  - 5G (OFDM)
  - 802.11ax
- Seamless "Session" handoff

- Numbers *may* drive bandwidth requirements

- 3GPP is considering GERAN for service to IoT

5G – The Vision

- Faster radio ~Gbps
- Low-latency wireless access ~ms
- Dynamic spectrum, multiple radio access technologies
- Next-gen network with improved support for emerging mobility services:

Mobile Data
(cellular, hetnet)

Vehicular Networks

Emergency Networks

Content Delivery

Internet-of-Things

Cloud Services

5G Network Architecture?
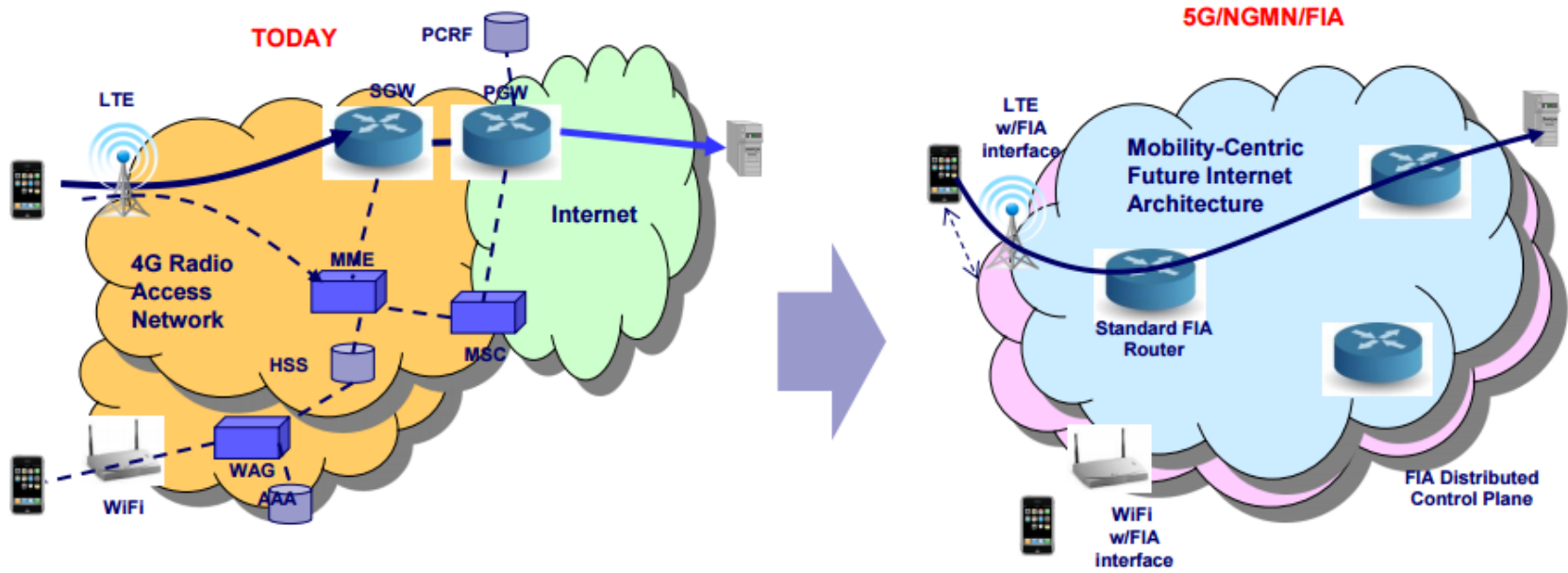
- Hybrid 3GPP & IP arch
- Complex control interfaces!
- Technology specific
- IP tunneling in data path
- Gateways (..bottlenecks, sub-optimum routing,..)

- Unified Internet/Mobile Net arch with integrated support for naming, authentication, mobility, etc.
- Simplified distributed control!
- Technology neutral –BS or AP plug-in
- Flat! No gateways or tunnels!
- Mobile devices as "first class" citizens

Mobility-centric Internet Protocol Architecture

- **Historic shift from PC's to mobile computing and embedded devices...**
  - Mobile data growing exponentially – 3.6 Exabytes in 2014, >> wired Internet traffic
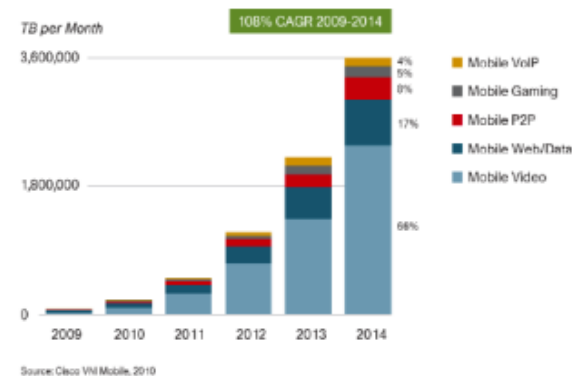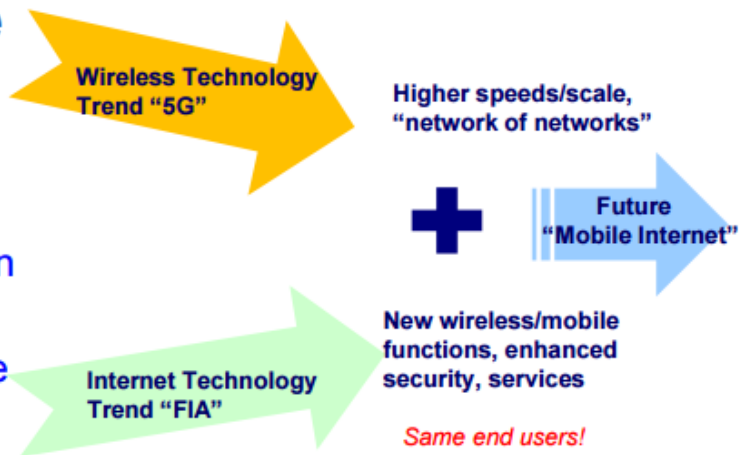 - Sensor/IoT/V2V ~5-10B units by 2020
  - Internet in 2020 all about mobile platforms & services

TB per Month — 108% CAGR 2009-2014

Legend: Mobile VoIP, Mobile Gaming, Mobile P2P, Mobile Web/Data, Mobile Video

Source: Cisco VNI Mobile, 2010

- **Inevitable convergence of mobile network and Internet industries**
  - Need to think beyond the "G"'s, associated with linear progression in mobile systems
  - Era of vertically integrated protocol stacks built on radio standards coming to an end
  - Single end-to-end protocol standard for the future mobile Internet!

Research Target of NSF Future Internet Architecture (FIA) MobilityFirst Project

Wireless Technology Trend "5G" → Higher speeds/scale, "network of networks"

Internet Technology Trend "FIA" → New wireless/mobile functions, enhanced security, services

Same end users!

+ Future "Mobile Internet"

Multi-homing for Service Continuity

- Multiple/heterogeneous radio access technologies (e.g. 4G/5G and WiFi) increasingly the norm
  - Improved service quality/capacity via opportunistic high BW access
  - Improved throughput in hetnet (WiFi/small cell + cellular) scenarios
  - Can also be used to realize ultra-high bit-rate services using multiple technologies, e.g. 60 Ghz supplement to LTE
  - Implications for naming and routing in the Internet

Multihomed devices may utilize two or more interfaces to improve communications quality/cost, with policies such as "deliver on best interface" or "deliver only on WiFi" or "deliver on all interfaces"
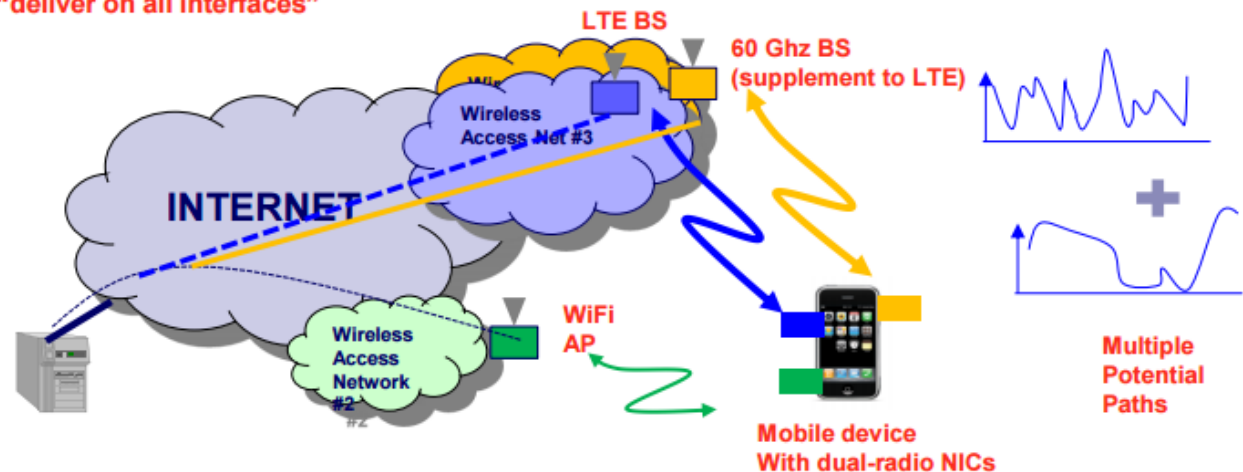
The Internet of Things (IoT)

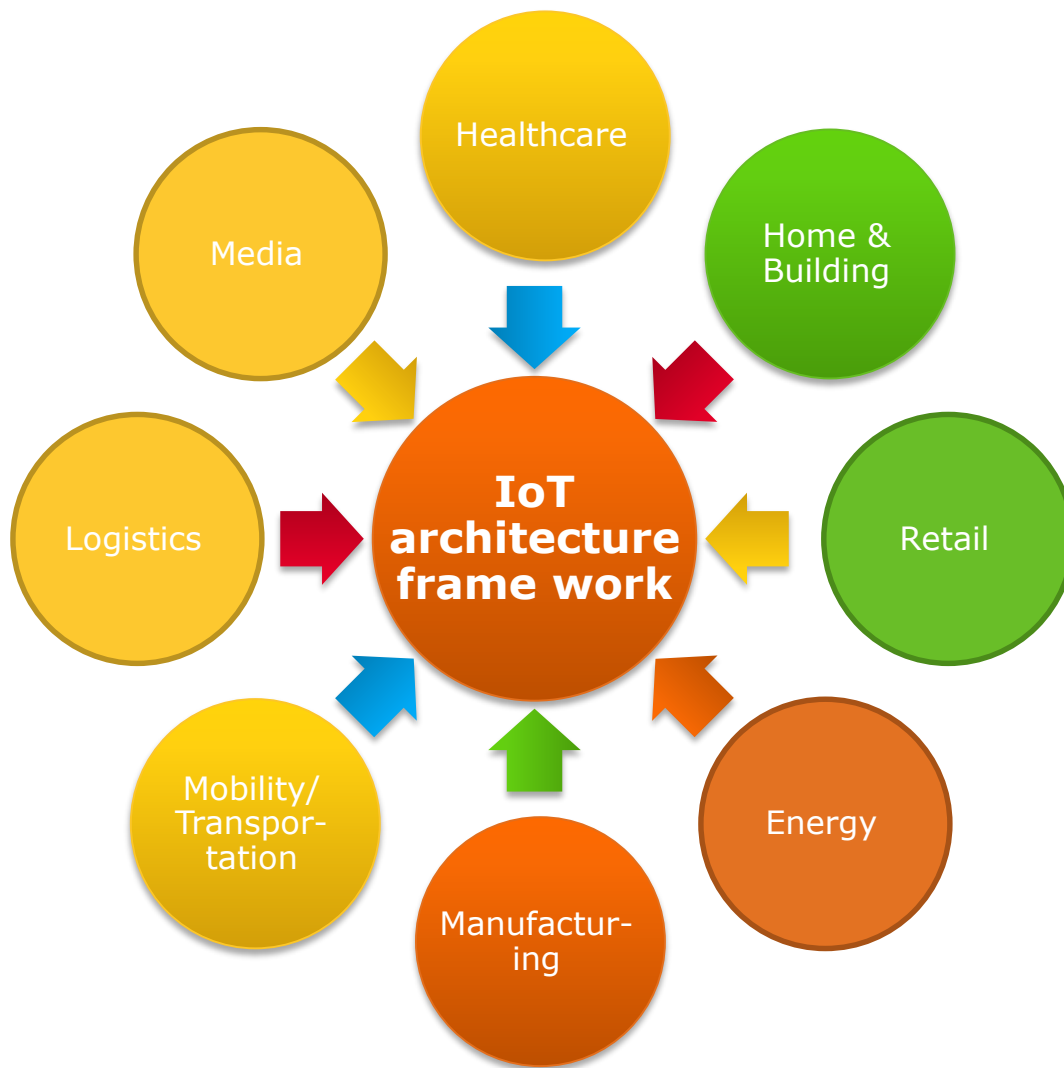- Sensors and Actuators
- Virtual Objects
- People
- Services
- Platforms
- Networks

- Low Bandwidth
- Possible high-volume
- 3GPP is considering GERAN
  - IoT over 2G technology

But what about Telematics?

◆IEEE

IoT Application Domains

*due to the diversity of IoT application areas only selected domains and stakeholders are shown

eHealth and Wireless Monitoring

Insulin Pump IEEE 11073-10419™

Cardiovascular Fitness & Activity Monitor IEEE 11073-10441™

Glucose Meter IEEE 11073-10417™

Weigh Scale IEEE 11073-10415™

Body Composition Analyzer IEEE 11073-10420™

Blood Pressure Monitor IEEE 11073-10407™

Sleep Monitor IEEE 11073-10423™

Electrocardiograph (ECG) IEEE 11073-10406™

Sleep Apnea Breathing Therapy Equipment IEEE 11073-10424™

Connectivity Transports

IEEE 802.3™ (Often referred to as Ethernet)

IEEE 802.11™ (Often referred to as WiFi®)

IEEE 802.15.4™ (Often referred to as Zigbee®)

IEEE 11073-30300™ (Often referred to as Infrared Communications)

IEEE 11073-30400™

Near Field Communications

Cloud IEEE P2301™ IEEE P2302™

Health Care Manager

Physician

World Wide Web

- **ISO/IEEE 11073 series** Health Informatics - Medical / Health Device Communication Standards

The Connected Vehicle

Advancing the Technologies for Connected Vehicles through Consensus Building

Connectivity
IEEE 802.3
Defining the physical layer and data link layer's media access control of wired Ethernet, in local area networks and wide area network applications.

Transportation Electrification
IEEE 2030 and its related standards are the first all-encompassing standards series providing alternative approaches and best practices for achieving smart grid interoperability.

IEEE 1547 Series
A series of standards for distributed power to maximize the benefits of interconnection.

IEEE P1562
Standard for array and battery sizing.

IEEE 1901 Series
Standards relating to broadband connectivity over electric power lines.

Traffic Safety
IEEE 1512
Multiple standards for traffic safety, hazardous materials and public safety incident communications.

IEEE 802.15
Wireless personal area networks allows the use of wearable and other short-range wireless devices (such as health monitors).

IEEE 802.20/802.21/802.22 Series
Communications standards for connecting vehicles to 802 systems.

Intelligent Transportation Systems
IEEE 1609
A family of standards defining the architecture, services and standard interfaces for secure vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications.

IEEE 1616
Standards for motor vehicle event data recorders.

IEEE 802.11
WLAN to support communication between vehicles and the roadside and between vehicles while operating at speeds up to a maximum of 200 km/h for communication ranges up to 1000 meters.

Cooperative, Autonomous and Automated Driving
IEEE P2040 Series
A series of standards for connected, automated and intelligent vehicles.

Smart Rail
A wide range of standards relating to electric rail operation including IEEE 11-2000, IEEE 16-2004, P1653.1, P1791, P1833, P1883, P1884, P1887, P1896, P2406,1536, 1558, 1568, 1570, 1628, 1629,1630, 1653 series, and 1698. As well as a series of standards relating to communication for rail transit systems, including IEEE 1473, 1474, 1475, 1476, 1477, 1482.1, and 1483.

And more...
IEEE Standards Coordinating Committee on Transportation (SCC42) leads the coordination of IEEE standardization activities for technologies related to transportation.

The Smart Home Initiative
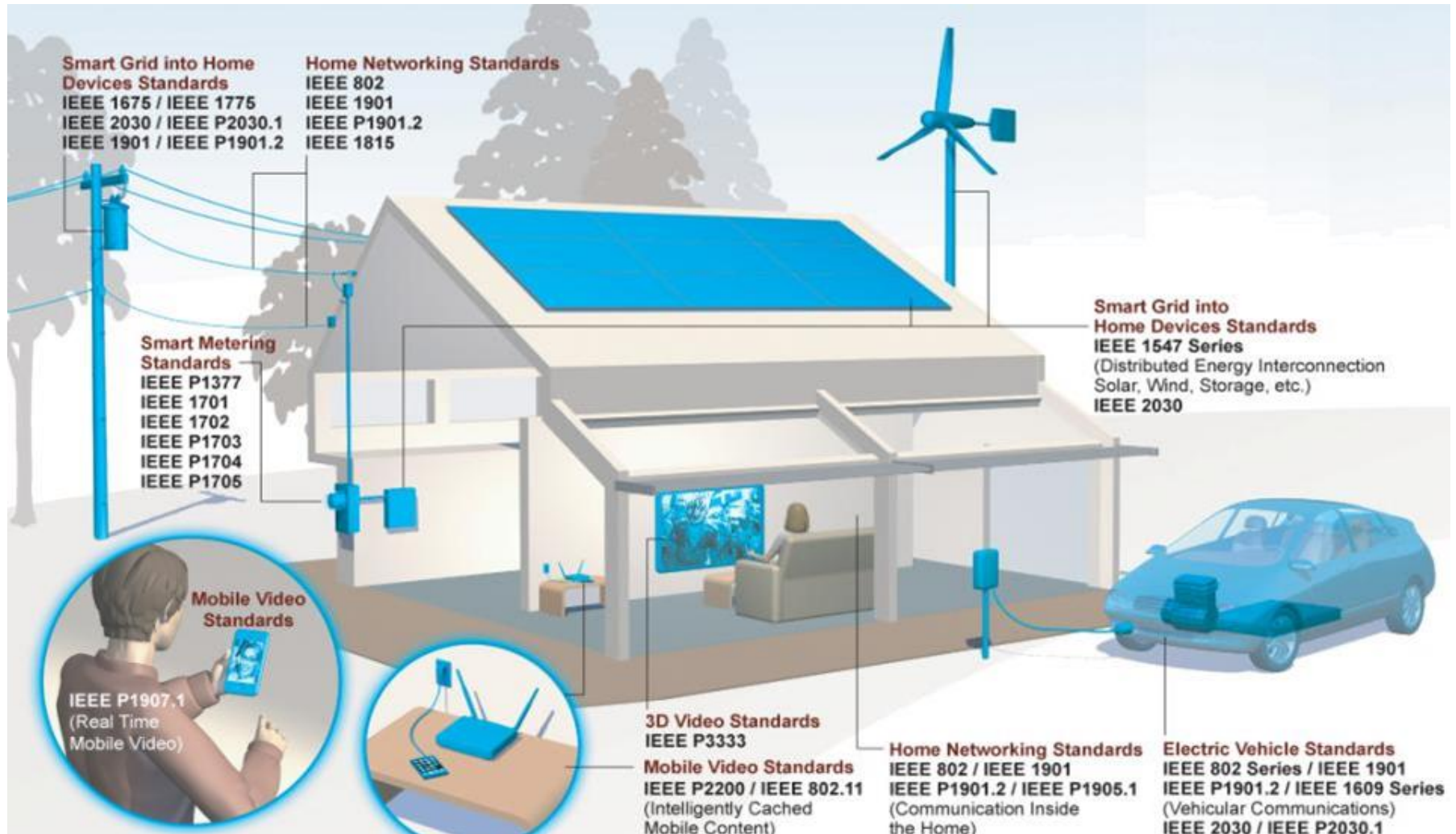
A few comments from your sponsor...

Institute of Electrical and Electronics Engineers (IEEE):
World's Largest Professional Association

Our Global Reach

430,000+	45	160
Members	Technical Societies	Countries

Our Technical Breadth

1,400	3,700,000+	160+
Annual Conferences	Technical Documents	Top-cited Periodicals

IEEE-SA Presence

- Globally recognized standards

- Clear IPR policy

- Approximately 1300 active standards

- More than 500 standards under development

- Over 7,000 individual members and 20,000 standards developers from every continent

- 200+ corporate members

- Leverages the breath of 40+ technical areas

- Smart Grid standards quoted in NIST

- Flagship transport layer standards in communications (IEEE 802)

- **Independent global community**

- Open standards process…

IEEE-SA Strengths

Different Paths: Standards Development

WELCOME

- Open membership, participation, and governance

- No restrictions

- Any individual or organization

- Includes academia

- Any industry or size of company

Individual Method

- Participants are individual technical experts
- Individuals represent themselves
- **Each individual participant has 1 vote**
- Ballot groups are made up of a minimum of 10 individuals
- Ballot group participants must be IEEE-SA individual members

Entity (Corporate) Method

- Participants are "entities," i.e., companies, universities, government bodies, etc.
- Designated representative and alternate represent the entity
- **Each entity has one vote**
- Requires 3 entities
- Entity sends representatives to meetings

Finally, a few thoughts on Standards…

Standards, Specifications, and OpenSource =

Collaboration
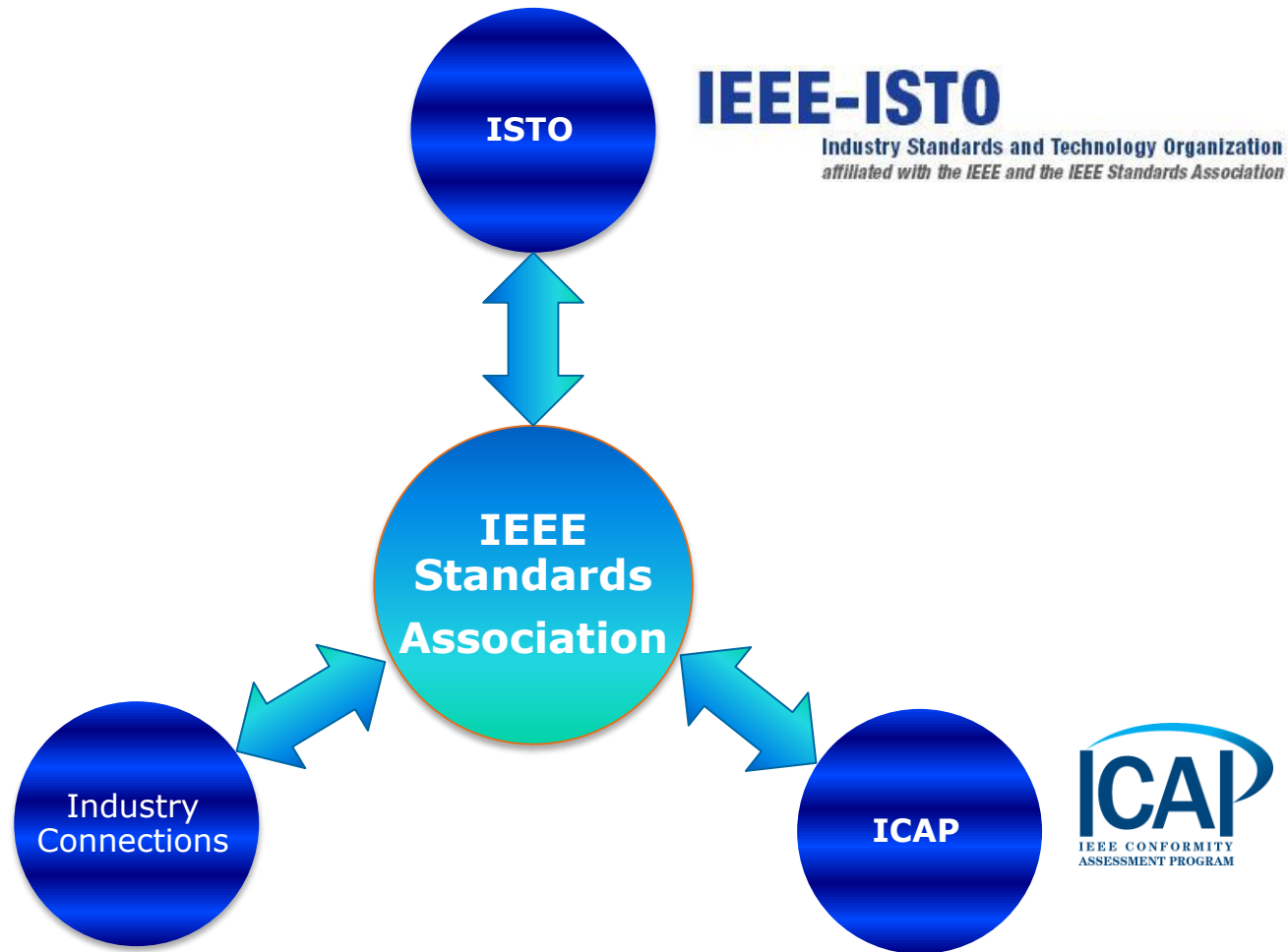
The Market Challenge of Standards

Benefits

- Establishes Developer Community

- Eliminates Customer Concerns with Sole-Sourcing

- Broadens Market Reach
  - Sole-source sales restricted to "must have"

- Reduces Production Costs

- Reduces R&D Costs

- Improves Interoperability
  - Affiliated Market Potential

Challenges

- IP Protection Issues
  - What do you protect/what do you expose?

- Competition
  - Must compete on:
    - Efficiency
    - Differentiation

- Cost/Resources
  - R&D Support
  - Standards delegate(s)

Tools for Collaboration

Thank You!