5G Initiative – "5G Roadmap" Working Group

Roadmap Breakdown Structure

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IEEE 5G

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Contribution: An era of continuous change

- A broad view of 5G and beyond – the transition to 5G will not be discrete but consist of continuous and rapid evolution of individual technology areas. The challenge is to find approaches that are long lived but at the same time can adapt to the underlying changes.
- When transitions happened between generations of wireless systems the approach has been to think of the successions as a definitive change from one state to another. An example would be the journey from analog to digital. This is no longer the case and 5G involves a large number of technologies which build on each other and will only accelerate the changes we have to adapt to.
- “Roadmaps” and the consensus that’s build around them are essential for anticipating these change and for developing strategies to exploit them. The first step is identifying the technologies that are driving the changes and coming to grips with how they influence each other. This has to be done at a fundamental and granular level that involves the worlds of mechanical, electronic, and software advances.

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Contribution: A transformation of the "Network"

- From the viewpoint of societal value, consumers, operators, industrial/commercial enterprises, and governments, "communications" is no longer a stand alone that can be optimized independently.
- More and more solutions and applications are utilizing public and private "networks" to provide solutions to what were previously well isolated single purpose uses, where each carried the responsibility for its own ecosystem, infrastructure, services, and domain specific equipment.
- The expectation that services will be come from a common external pool has profound impacts on our view of "networks" and the functionality and resources they represent. "Networks" are platforms. The bundle or composition of underlying capabilities and attributes in the "network" will only continue to grow! It includes: communications, computing, storage, and new core capabilities that rely on infrastructure that is cross industry – it is convergence at many levels.

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Contribution: Confronting Future Network Complexity at a System Level

- The practical design, development, deployment, operation, and upgrade of future “Networks” is a complex undertaking that feeds of “hyper alignment” – processes that involve a great numbers of stake holders, many points of view, international and governmental organizations, and a plethora of convening bodies. The participants hopefully reach consensus on core aspects of the “Network” Architectural Guidelines that actually work. The convergence that is occurring further compounds the problem by bringing many new players to the table. It is a process with lots of influencers but no one in charge!
- In this setting it is an advantage to inform the process by constructing a well developed and as complete a view as possible of the driving issues, key capabilities, attribute requirements, and technology trade-offs, and economics. A must is to capture the influence of “time” and the interplay between the building block technologies – this is best conducted in the framework of a System Analysis.

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Breakdown for 5G Elements

- 5G Building Block Wireless Technologies
  - ✓ Radio and Air Interface
  - ✓ Antennas and Signal Processing
  - ✓ Key Components
  - ✓ Densification
- 5G Building Block Network Technologies
  - ✓ Virtualization of Network Functions
  - ✓ Automation
  - ✓ Dynamic Network Management
  - ✓ Integrated Network Systems – Fixed, Space, and Wireless
- 5G Building Block Service Enablement Technologies
  - ✓ Cloud, Mist, and Fog Computing
  - ✓ Storage
  - ✓ Orchestration Platforms and Integration

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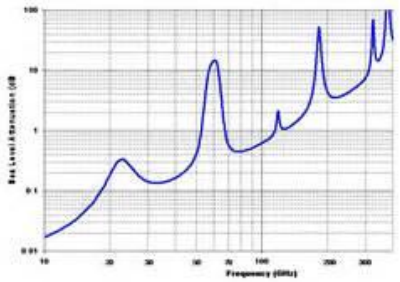
- A Few Examples

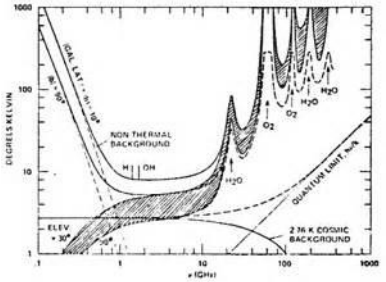
Breakdown for 5G Wireless Elements

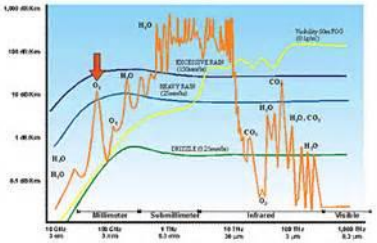
- Spectrum for Wireless Technologies

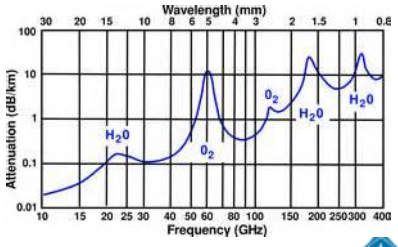
  Balanced use within 5G Architectures – How to best exploit what's available to solve specific problems – area coverage, bandwidth, urban vs. rural environments, building penetration, combine wireless with fixed infrastructure, resource sharing, propagation in difficult terrains, imperviousness to weather, effects of foliage, health and safety, etc. It is also crucial to achieve universality in spectrum use globally for both scale and interoperability. The objective is to capture how technologies improve efficient use of spectrum, allow sharing in novel ways, and promote complementarity between licensed and unlicensed regimes.

  - Prime Frequencies 400.0 MHz – 2.0 GHz
  - Low Frequencies 2.0 GHz – 6.0 GHz
  - Medium Frequencies 6.0GHz – 20.0 GHz
  - High Frequencies 20.0 GHz -100.0 GHz +









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Breakdown for 5G Wireless Elements

- Wireless Technologies

  Maturity of manufacturing and supply chains to satisfy the needs of 5G deployment, functionality, attributes, and economics to match required capabilities. Design of the air interfaces at various levels of the communication hierarchy (on device, between proximate devices, LAN, WAN, ….), processing schemes and the required hardware, physical components that range from amplifiers to switches to buffers.

  - Prime Frequencies 400.0 MHz – 2.0 GHz
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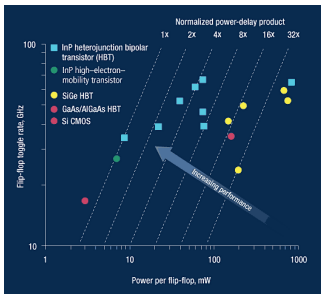
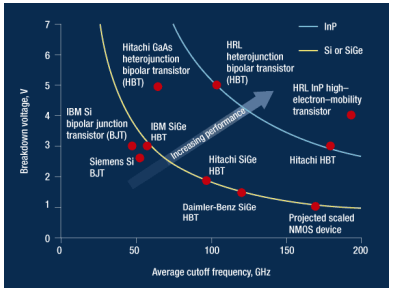
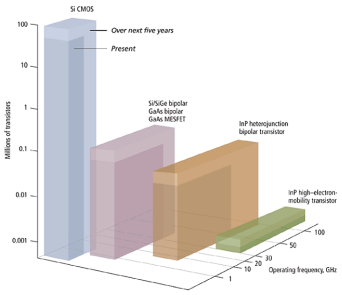
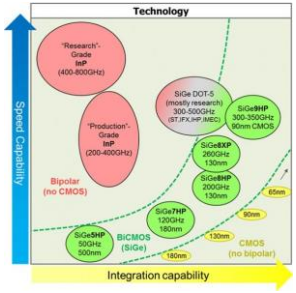
  - High Frequencies 20.0 GHz -100.0 GHz +
    - Materials Performance









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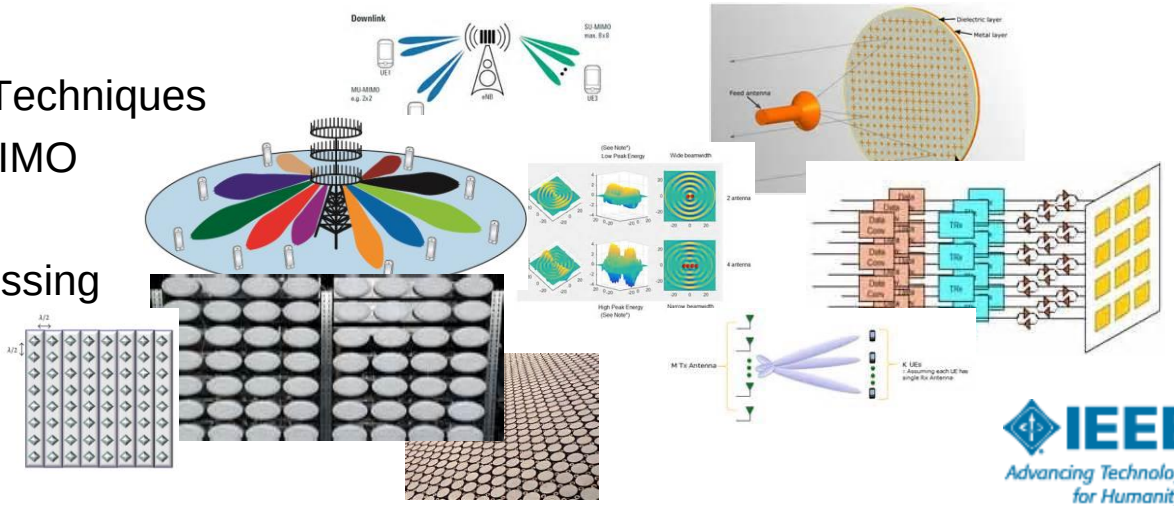
Breakdown for 5G Wireless Elements

- Antennas and Signal Processing for Wireless Technologies

  Maturity of components and supply chains for various elements of 5G architectures ranging from base stations, to a variety of small cells, to various forms of user equipment. We don't manufacture spectrum – in the end efficiency becomes a driving factor – practical techniques and methods vary by significantly over the spectrum that's used.

  - Prime Frequencies 400.0 MHz – 2.0 GHz [75.0cm - 15.0cm]
  - Low Frequencies 2.0 GHz – 6.0 GHz [15.0cm - 5.0cm]
  - Medium Frequencies 6.0GHz – 20.0 GHz [5.0cm - 1.5cm]
  - High Frequencies 20.0 GHz -100.0 GHz + [1.5cm - 0.3cm]

- Antenna and Processing Techniques
  - MIMO and Massive MIMO
  - Beam Forming Arrays
  - Adaptive Signal Processing
  - Holographic Arrays
  - Coding and EC



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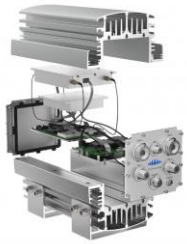
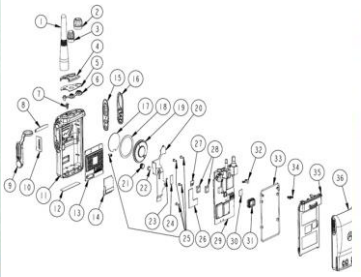
Breakdown for 5G Elements

- Equipment

  Maturity of components and supply chains for various elements of 5G architectures ranging from base stations, to a variety of small cells, to various forms of user equipment. Packaging and operation of multiple radios within the same device, use of common components such as signal processing elements, amplifiers, and at the same time continued “softwarization” of payload, management, and control functions.

- Equipment Types and Devices
  - Mobile
  - Nomadic
  - Fixed
  - Hybrid
  - Gateways for Aggregation, Dis-Aggregation, and Routing (CPE)

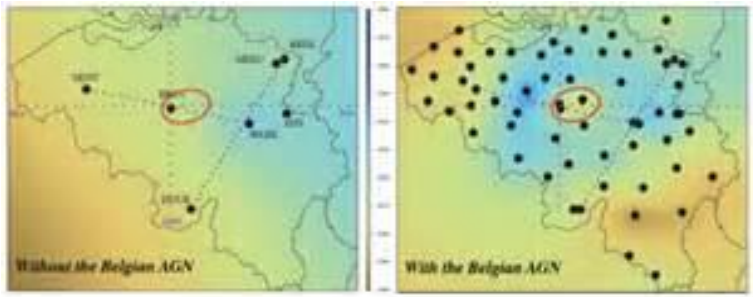



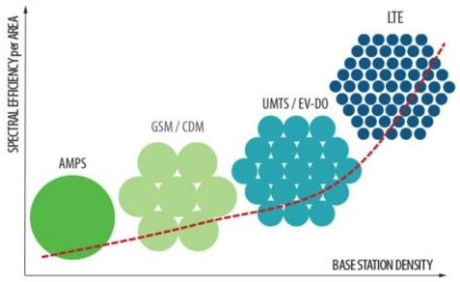



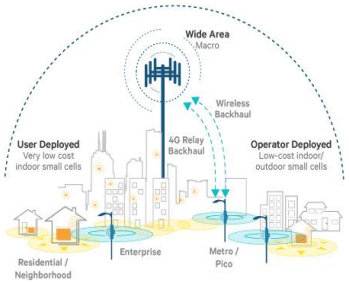

Breakdown for 5G Elements

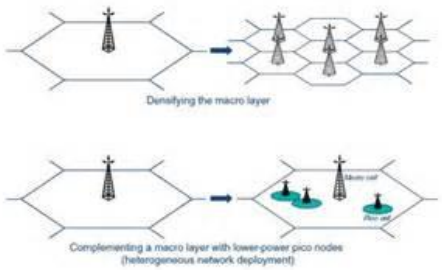
- Densification

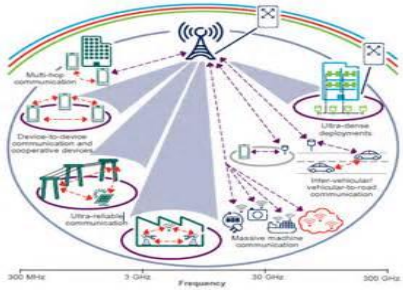
  Ability to maintain efficient systems that can be controlled and operated at three level – efficient payload delivery, stable control, and management functions at scale. Integration with support systems and utility functions such as power. Avoidance of interference.











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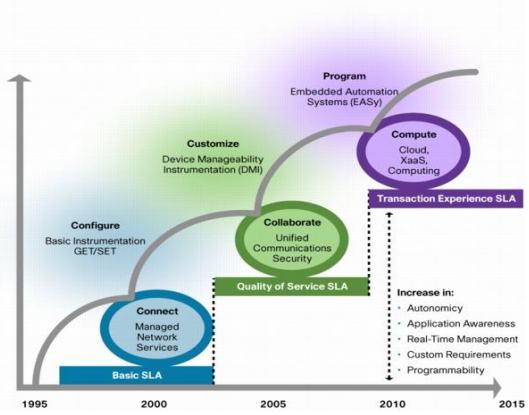
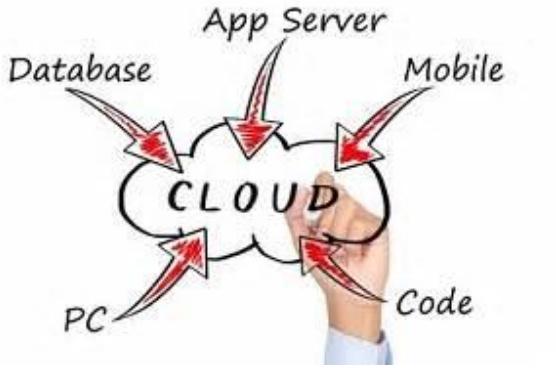
Breakdown for 5G Elements

- Network Automation

  Maturity of algorithms and Operational Support Systems that progressively drive greater degrees of autonomy – low levels of fallout while providing high reliability and availability across the network. Dynamic Network Management to accommodate demand swings by time and location.





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- Thank You!