“5G and the Digital Revolution”

IEEE 5G World Forum

Santa Clara, CA USA
July 10th, 2018

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Wayne, PA 19087
Outline

• 5G and the Digital Revolution
  • Thinkers and Futurists
  • Stakeholders and Markets
  • Technologies in the Trenches – Dimensions of 5G
• A few questions to ponder
To Start with – a Toast to 5G!
Deep Digitization

**digitization**

ˌdijədəˈzæSH(ə)n/

noun: digitization; noun: digitisation

The conversion of text, pictures, or sound into a digital form that can be processed by a computer.

From Google

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Deep Digitization

From Google

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From Mary Meeker – Internet Report

Acceleration of Technological Adoption Curves 1867-2017

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From Wikipedia

Digitization less commonly digitalization, is the process of converting information into a digital (i.e. computer-readable) format, in which the information is organized into bits. The result is the representation of an object, image, sound, document, signal (usually an analog signal) by generating a series of numbers that describe a discrete set of its points or samples. The result is called digital representation, more specifically, a digital image, for the object, and digital form, for the signal. In modern practice, the digitized data is ........

Digitization is of crucial importance to data processing, storage and transmission, because it "allows information of all kinds in all formats to be carried with the same efficiency and also intermingled". Unlike analog data, which typically suffers some loss of quality each time it is copied or transmitted, digital data can, in theory, be propagated indefinitely with absolutely no degradation. ...........
Deep Digitization

Six Aspects of what’s involved and what’s important

- **Data**: Data strategy, data collection, storage and analysis, curation, data-driven decision-making, policy and regulation. (Volume, Velocity, and Variability)
- **Connectivity**: Sensor and computing usage in: production and output equipment and plants; goods and products; embedded in services; and on the Network.
- **Adaptability**: Customization capability; Design tools to model outcomes robustly, a high degree of automation.
- **Integration**: Enterprise, Supply-chain, Service Provider, and User data; as well and Computation, Storage, and Interface Integration.
- **Security**: Built in by design, at a system level, and dynamic.
- **People**: Inside skills and training, end users literacy, well informed regulators and policy makers.
• A View from Futurists and Thinkers
A View from Futurists and Thinkers

*Thomas Kuhn: “The Structure of Scientific Revolutions”*

*Derek John de Solla Price: “Science Since Babylon”*

*Ray Kurzweil: “The Singularity is Near”*

*Roy Amara: Amara’s Law*

"*We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.*"
A View from Futurists and Thinkers

Alvin Toffler: "Future Shock"

Quotes

"You’ve got to think about big things while you’re doing small things, so all the small things go in the right direction."

“The future always comes too fast and in the wrong order.”

“Technology feeds on itself. Technology makes more Technology possible.”
A View from Futurists and Thinkers


Geoffrey Moore: ”Crossing the Chasm”

Michael Hammer and James Champey: “Re-engineering the Corporation”
A View from Futurists and Thinkers

Gideon Gartner: The Magic Quadrant and the Hype Curve

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5G and the Digital Revolution
A View from Futurists and Thinkers

Grace Hopper

Clayton Christensen

Marshall McLuhan

Winston Churchill

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**Winston Churchill: On Architecture, Process, and Endurance**

*We shape our buildings; thereafter they shape us.*

Plans are worthless, but planning is everything.

- Winston Churchill

*“SUCCESS IS THE ABILITY TO GO FROM ONE FAILURE TO ANOTHER WITH NO LOSS OF ENTHUSIASM!”*  

**Grace Hopper: Nature of Change, Leadership, and Facts**

The most dangerous phrase in the language is ‘We’ve always done it this way.’

– Grace Hopper

**One accurate measurement is worth a thousand expert opinions**

If it's a good idea... go ahead and do it. It is much easier to apologize than it is to get permission.
Marshall McLuhan: The importance and impact of Media

Clayton Christensen

Disruptive Innovation Cycle

Source: Clayton Christensen, The Innovators Solution

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5G and the Digital Revolution
• Stakeholders and Markets
Stakeholders and Markets

TIME SPENT PER DAY ON THE INTERNET
AVERAGE NUMBER OF HOURS SPENT USING THE INTERNET PER DAY VIA ANY DEVICE (SURVEY BASED)

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Stakeholders and Markets

Nielsen Survey Data 2018
Stakeholders and Markets

Ericsson Mobility Report June 2018

4X growth in mobile broadband subscriptions in Middle East and Africa between 2015 and 2021

Mobile broadband subscriptions by region (billion)

- Latin America
- North America
- Asia Pacific
- Middle East and Africa
- Central and Eastern Europe
- Western Europe

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Ovum Analytics 2018

Global Monthly Mobile Data Traffic, By Type

BI Intelligence 2018

Cisco Visual Networking Index 2018

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Stakeholders and Markets

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5G and the Digital Revolution
Stakeholders and Markets

Operators and Service Providers

Network Equipment and Infrastructure Suppliers

User Equipment And Service Suppliers

Technology, Development and Research Organizations

Policy Makers And Regulators

Users
- Consumers
- Commercial Enterprises (LMS)
  - Internal Operations
  - Customer Facing
- Government
  - Internal Operations
  - Citizen Facing Services

Investment and Financial Institutions

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5G and the Digital Revolution
Stakeholders and Markets

End Users

Consumer Electronics Ind.

Content

3GPP

User Demand

Technology and System Specifications

ITU

Spectrum Harmonization

5G and the Digital Revolution

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• Technologies in the Trenches – Dimension of 5G
Technologies in the Trenches – Dimension of 5G

• The 5G Technologies Basket
Technologies in the Trenches – Dimension of 5G

- The 5G Technologies Basket

3GPP is a distributed, systems-engineering effort
Technical work occurs across 3 TSGs and 16 specialized WG

Radio Access Network (RAN)
- Defines the radio communications between UEs and core network
  - RAN WG1: Layer 1 (Physical) spec
  - RAN WG2: Layer 2 and 3 (RR) protocols
  - RAN WG3: Access network interfaces + O&M
  - RAN WG4: Performance requirements
  - RAN WG5: UE conformance testing
  - RAN WG6: Legacy RAN, e.g. GSM, HSPA

Service/System Aspects (SA)
- Responsible for overall architecture & service capabilities
  - SA WG1: Service requirements
  - SA WG2: Architecture
  - SA WG3: Security
  - SA WG4: Codecs, multimedia system
  - SA WG5: Telecom management
  - SA WG6: Mission-critical services

Core network & Terminals (CT)
- Responsible for core network; defines terminal interfaces & capabilities
  - CT WG1: Mobility Mgmt, Call Ctrl, Session Mgmt
  - CT WG3: Policy, QoS and Interworking
  - CT WG4: Network protocols
  - CT WG6: Smart card application

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Technologies in the Trenches – Dimension of 5G

- The 5G Technologies Basket

From Qualcomm
## Technologies in the Trenches – Dimension of 5G

### The 5G Technologies Basket

<table>
<thead>
<tr>
<th>5G New Radio</th>
<th>Sub-6GHz</th>
<th>Licensed</th>
<th>Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>mmWave</td>
<td>Unlicensed</td>
<td>Fixed (Access)</td>
<td></td>
</tr>
</tbody>
</table>

**Antennas**

<table>
<thead>
<tr>
<th>MIMO</th>
<th>Adaptive (Processing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Forming</td>
<td>Reconfigurable (Physical)</td>
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**Signal Processing**

<table>
<thead>
<tr>
<th>256 QAM</th>
<th>Multiple Access Technologies</th>
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</table>
## Technologies in the Trenches – Dimension of 5G

**The 5G Technologies Basket**

<table>
<thead>
<tr>
<th>LTE</th>
<th>Network Co-Existence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wideband</td>
<td>Fixed Networks</td>
</tr>
<tr>
<td>Licensed</td>
<td>Fiber, Cable, Copper</td>
</tr>
<tr>
<td>Narrow Band</td>
<td>Local (WiFi)</td>
</tr>
<tr>
<td>Unlicensed</td>
<td>Platforms</td>
</tr>
<tr>
<td></td>
<td>Satellites (LEO, MEO,</td>
</tr>
<tr>
<td></td>
<td>GEO) UAVs, etc.</td>
</tr>
</tbody>
</table>
Technologies in the Trenches – Dimension of 5G

- The 5G Technologies Basket

- Latency and Jitter
- Bandwidth
- Connection Density
- Spectrum Efficiency
- Dynamic Flexibility
- Energy Efficiency
- Automation
Technologies in the Trenches – Dimension of 5G

- The 5G Technologies Basket

- New Core
- New Radio
- Small Cells And Heterogeneity
- Tight Integration (Computing and Storage)
- Virtualization
- Aggregation
Technologies in the Trenches – Dimension of 5G

- The 5G Technologies Basket

  Digitization Of Applications

  Connectivity
  Computing
  Storage
  Sensors
  Actuators
  Interfaces
  Software

  Design and Analysis
  Integration
  Operation
  Power and Energy

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5G and the Digital Revolution
• A few questions to ponder
A few questions to ponder

- Of the Technologies that are part of 5G
  - Which will attract the resources needed to meet established and projected market requirements
  - What surprises can we anticipate
  - Which are mature enough to make the cut
    - Are field ready in time for deployment
    - Or can catchup and be compatible with “invested early decisions”
  - Which technologies won’t make the cut but have enough promise that they will compete with what we are institutionalizing
  - Which introduce new problems, vulnerabilities, and disruptions that we have not experienced as yet
A few questions to ponder

• With the expected performance for 5G, are Cellular Systems stand alone, or are we now dealing with one network in which the 5G technology plays an important role for both access and mobility?

• What should drive the Architecture for Future Networks?
  – Is it the underlying Communications Technologies?
  – Or is it the outcomes from the tradeoffs for Data, Computing, and Storage – because they are increasingly where value comes from?
A few questions to ponder

• The History of discrete transitions in Network Technologies tells us that 5G is not the end-all and that it will eventually need upgrading or replacement.
  – How long will 5G last and will we see 6G?
  – Is there a better model for ingesting capabilities in a world of continuous technological change than discrete generations?
• You ain’t seen anything yet!

THIS COMPUTER

DOES NOT HAVE ENOUGH INTERNET