Challenges for LTE and 5G

Panel Discussion
Participants

● **Moderator:**
  - Sergei Semenov, Huawei/HiSilicon, Sweden

● **Panelists:**
  - Josef Noll, Basic Internet Foundation #Basic4All | University of Oslo (UiO) / ITS, Norway
  - Bernhard Tellenbach, Zurich University of Applied Sciences, Switzerland
  - Gerson Damanik, Satya Wacana Christian University, Indonesia
Problems of 4G

- **Technology considerations:**
  - Data traffic increases.
  - Requirements for speed, latency and capacity are increasing.
  - High volume of control information per user.

- **Business considerations:**
  - While data traffic increases, operators are facing stagnating revenues => CAPEX constraints => infrastructure manufacturers’ revenue decreases.
  - Operators are looking for growth areas and ways to reduce cost.
Possible drivers for 5G

- 8K UHDTV: ~ 500 Mbps (7680 x 4320 x 30 fps)
Possible drivers for 5G

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● VR/AR: 1.5 – 3 Gbps (16K x 120 fps), 20 ms latency
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- Most probably 5G rollout will be a gradual process (evolution) driven by the potential of use cases, rather than a massive spending.
- Fixed Wireless Access (FWA) is a priority case for operators followed by eMBB and IoT.
Main Enablers

● mmWave spectrum
● Beamforming

● Opportunities:
  ▪ FWA:
    □ should be able to provide equivalent capacity to fixed BB.
  ▪ eMBB:
    □ Dedicated networks to high value customers;
    □ TV, Media
  ▪ IoT:
    □ VR/AR;
    □ Self-driving cars
Challenges

● mmWave
  ▪ Short range of mmWave,
  ▪ Sensitivity to blockages,
  ▪ Variable propagation laws:
    ▪ Weaker diffractions due to the small wavelength => very big difference in pathloss between LOS and NLOS
  ▪ High phase noise.

● Beamforming
  ▪ High complexity
  ▪ Pilot contamination
Challenges

- Operators will deploy 5G as hotspots to address specific use cases and utilize existing 4G infrastructure as a fall back option => coexistence with 4G.
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- Using mmWave bands entails more dense network => higher costs:
  - Need to integrate alternative technologies:
    - Wi-Fi
    - Satellite communications
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    - Satellite communications
- Growth of number of users and data traffic increase leads to greater importance of security aspects.
- Mobile operators cover less than 1% of IoT business and the projection to 2020 is 3% - 6%.
  - But should the world of IoT belongs to mobile operators?
Panel Topics

- **Josef Noll**, Basic Internet Foundation #Basic4All | University of Oslo (UiO) / ITS, Norway
  - 5G and Sustainability?
- **Bernhard Tellenbach**, Zurich University of Applied Sciences, Switzerland
  - Cybersecurity aspects of 5G
- **Gerson Damanik**, Satya Wacana Christian University, Indonesia
  - Satellite Deployment model in Indonesia
- **Sergei Semenov**, Huawei/HiSilicon, Sweden
  - Phase Noise Compensation
Phase Noise Compensation

Sergei Semenov

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Phase Noise model.

- **Ideal oscillator model:**
  \[
  \alpha_{\text{osc}}(t) = e^{j2\pi f_c t}
  \]

- **Noisy oscillator model:**
  \[
  \alpha_{\text{osc}}(t) = e^{j2\pi f_c t} e^{j\phi(t)}
  \]
  - $f_c$ is the carrier frequency
  - $\phi(t)$ is the phase noise

- Phase noise (PN) reflects time-varying phase behavior of the oscillator.

- Simplest PN model is a free-running oscillator.
  - PN is a Wiener process.

- Phase locked loop (PLL) is more realistic PN model.
  - Includes few different components, e.g. flicker noise and Wiener process.
Phase noise PSD.

- PN is defined by its power spectral density (PSD).
  - The oscillator PSD level increases by 20dBc/Hz per decade of increase of the carrier frequency.
PN impact on OFDM system

- **OFDM signal in time domain after IFFT:**

  \[ x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi kn/N}, \quad n \in \{0, \ldots, N - 1\}. \]

  - \(X_k\) is a QAM transmitted symbol,
  - \(N\) is a DFT length

- **Signal vector of length \(N\) is appended by CP and transmitted over the channel.**

- **Received signal after CP removal:**

  \[ y = \text{diag}(e^{j\Phi})(x \otimes h) + w \]

  - \(h\) is vector of channel coefficients,
  - \(w\) is noise vector
  - \(\Phi\) is current PN realization \(\Phi = [\phi_0, \phi_1, \ldots, \phi_{N-1}]\)
  - \(\otimes\) denotes circular convolution
PN impact on OFDM system (2)

- Received signal in frequency domain after DFT:

\[ Y_k = X_k H_k J_i + \sum_{n=0, n \neq k}^{N-1} X_n H_n J_{k-n} + W_k \]

- \( J_i \) is the PN component in frequency domain

\[ J_i = \frac{1}{N} \sum_{n=0}^{N-1} e^{j \phi_n} e^{-j 2\pi n i / N} \]

- PN can be split in 2 parts:
  - Common Phase Error (CPE);
  - ICI
PN example in time domain
Constellation of a received symbols corrupted by phase noise
CPE compensation

- Currently CPE only estimation/compensation is the main direction in 3GPP.
- Phase Tracking Reference Symbols (PTRS).
- Simplest method. LS estimation:
  - Get raw channel estimates with the help of PTRS.
  - Get LS estimate of $J_0$

$$
\hat{J}_0 = \frac{\sum_{k \in S_P} Y_k X_k^* H_k^*}{\sum_{k \in S_P} |X_k H_k|^2}
$$

- $S_P$ is the set of PTRS in current OFDM symbol
Different PN models

- CPE compensation only may be sufficient or not depending on PN model.
PN ICI compensation.

- Complexity of PN ICI estimation is prohibitively high.
- Solution:
  - Approximate PN with small amount of PN spectral components.
PN ICI compensation.

- Complexity of PN ICI estimation is prohibitively high.
- Solution:
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MMSE estimation

\[
\begin{bmatrix}
Y_{l_1} \\
Y_{l_2} \\
\vdots \\
Y_{l_P}
\end{bmatrix}
=egin{bmatrix}
A_{l_1} & \ldots & A_{l_1+2u} \\
A_{l_2} & \ldots & A_{l_2+2u} \\
\vdots & \ddots & \vdots \\
A_{l_P} & \ldots & A_{l_P+2u}
\end{bmatrix}
\begin{bmatrix}
J_0 \\
J_1 \\
\vdots \\
J_{u}
\end{bmatrix}
+ \begin{bmatrix}
\Omega_{l_1} \\
\Omega_{l_2} \\
\vdots \\
\Omega_{l_P}
\end{bmatrix}
+ \begin{bmatrix}
W_{l_1} \\
W_{l_2} \\
\vdots \\
W_{l_P}
\end{bmatrix}
\]

\[A_k = X_k H_k\]

\[Y = AJ_u + \varepsilon\]

\[\hat{J}_u = MY\]

\[M = R_{J_u J_u} A^H (A R_{J_u J_u} A^H + R_{\varepsilon \varepsilon})^{-1}\]

- High complexity but could be affordable
Thank you

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Panel on AICT/ICIMP/ MOBILITY
Challenges for Long-Term Evolution
and 5G for IoT Systems

-- Security --

Dr. Bernhard Tellenbach,
Zurich University of Applied Sciences, Switzerland
Our Current Approach to Security

- TOWER (Application Security)
- INNER WALL (Internal Network)
- OUTER WALL (Perimeter Security)
- MOAT (Policies, Procedures Awareness)
- DRAWBRIDGE (Physical Security)
Does this approach work?

The computer network of the Swiss foreign ministry has been the target of a "very professional" attack, officials said on Monday evening.

Security today: Assume you’ve been hacked!

“We’re in the dark ages of cyber security.”
[Amit Yoran, RSA president]
In order to stop the onslaught of continued DDOS, Ransomware and other forms of threats and attacks we must build security into next generation infrastructures and devices.

Secure by Design must be part of our strategy moving forward

How do we achieve this? How can it be implemented and how expensive and difficult would this be?

- Does improve the training of our future engineers help?
- Do we need to extend international product liability to IT security flaws and problems caused by the products?
- Do we have to have something like a “drivers license” for people buying and using these devices and infrastructures?
• The Cybersecurity threat is dynamic; it is a constantly evolving arms race of threat and remediation where the advantage lies with the attacker.
• Can we change this or are we playing a game that we already lost? How do we have to build 5G and IoT infrastructures to avoid this?
  • Currently, vulnerable standards have a long live… (e.g., SS7)
AICT/ICIMP/ MOBILITY Panel,
Challenges for Long-Term Evolution and 5G for IoT Systems
Mestre (IT), 26 June 2017

5G and Sustainability?

Josef Noll
Basic Internet Foundation / University of Oslo
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Internet is a basic human right

- Is Internet access and online freedom of expression a basic human right?
- “All people should be allowed to connect to and express themselves freely on the Internet.“

- The United Nations’ Human Rights Council unanimously backed that notion in a resolution on **5 July 2012**. All 47 members of the Human Rights Council including China and Cuba signed the resolution.
Connectivity & Affordability

- Mobile supported development
- Affordability (costs of data)
- Industrial perspective (Ind4.0)

Source: GSMA, Nov2015
IoT expected impact, only for “the connected”? 

- Smart home appliances, “wearables”, smart metering, autonomous vehicles,…
- Total global impact: US$ 2.7 - 14.4 trillion by 2025
- ~\frac{3}{4} of devices from IoT++
- ~\frac{1}{4} from tablet, mobile,…

Source: John Greenough, “The Internet of Everything 2015,” Business Insider Intelligence. Produced by Adam Thierer and Andrea Castillo, Marcatus Center at George Mason University, 2015.
5G - demand: “Connect the Unconnected”

5G - demand: “Connect the Unconnected”  

![Diagram showing the relationship between access, need/desire, and ability leading to limited use and eventually creation.](source: GSMA, Nov2015)

**Telecom focus on**

- **no use**
- **limited use**
- **leverage**
- **creation**

**Partnership for digital inclusion**

<table>
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<tr>
<th>Telecom</th>
<th>Infointernet</th>
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<tr>
<td>revenue-driven</td>
<td>non-profit</td>
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<tr>
<td>targeting leveraged creation</td>
<td>targeting no- and limited use</td>
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<tr>
<td>voice &amp; mobile broadband</td>
<td>compressed text &amp; pictures</td>
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<td>subscription based (SIM)</td>
<td>free access &amp; voucher</td>
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<td>mobile network: coverage &amp; capacity</td>
<td>Wifi-spots: health-/community centres, schools</td>
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<td>operator cost model</td>
<td>target: 0.5 US$/month</td>
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<tr>
<td>operator roll-out</td>
<td>NGO &amp; community roll-out</td>
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**Notes:**

- “Internet is my teacher”
- “I’m currently learning Python and HTML, so I can make a website for my parents’ business”
Main Objectives of CTU

1. Create the Showcase Digital Tanzania
2. Catalyst for SDG 2030, Showcase for Digital Africa
3. Combined effort of IT industry, World Bank, Telecom

Goal: Include people with 1 USD/month for communications

Free local info
- health
- education

1. UN sustainability goals and Agenda 2030:
Germany has chosen this agenda as a backdrop for their entire program for the presidency, and I lead a group at the United Nations that will drive towards implementation.

We will work to ensure that the G20 goes ahead with its own specific commitments to help achieve sustainability goals.

Information for all (InfoInternet)
- free access to text and pictures
  - the “walk on the Internet”
- paid access to amusement
  - “Toll Roads”

The catalyst for the SDGs
Satellite Deployment through a Two-Layer Function Model to Solve a National Supply and Demand Gap of Capacity in Indonesia

IARIA CONFERENCE, 2017

Venice, 26 June 2017

Gerson Damanik

Satya Wacana Christian University, Salatiga, Central Java, Indonesia
The largest archipelago country: 13,466 islands (already have coordinates and registered) source: Geospasial Information Indonesia (BIG) May 2014

Total land area: 1,919,440 km² (land: 1,826,440 km², inland water: 93,000 km²) source: statistics Indonesia (BPS) May 2014
Overview: Indonesia Information Structure

### Backbone Network: Fiber Optic

Currently, terrestrial backbone and access network have not covered all Indonesian territory, especially in Eastern Part of Indonesia due to geographic condition.

- **Satellite plays an important role in connecting Indonesian territory and serving the unserved areas.**
- **Indonesia is highly dependent on satellite.**

### Access Network: Cellular network

The white space represents blank spots areas for wireless infrastructure that are mostly located in the eastern part of Indonesia.
Overview: Foreign Satellite Usage in Indonesia

- **Cellular Backhaul**: 3.6 GHz, 65%
- **Plantation**: 2.4 MHz, 4%
- **Mining**: 205 MHz, 4%
- **Telecommunication**: 234 MHz, 4%
- **Broadcasting (DTH)**: 1.4 GHz, 24%
- **Government Institutions**: 61.8 MHz, 1%
- **Banking**: 78.6 MHz, 1%
- **Others**: 27 MHz, 1%

Total: 5.6 GHz
Why Satellite

- Satellite is a vital infrastructure for national security, national telecommunication infrastructure, broadcasting service, and earth observation purposes.

- Satellite is suitable with Indonesia geography.

- Indonesia satellite market showed supply and demand gap condition, where the most of satellite usage was provided by foreign satellites. There were 34 for foreign satellites used in Indonesia that served by 15 countries.
Main Problem with Indonesian Operators

Based on the result of interview be conducted, the problem with Indonesian satellite operators such as:

- lag of investment
- inword looking orientation
- too many national satellite operators with minimum real satellite in operate.
Satellite Launching Process

- Satellite planning and design according to national need.
- Submit satellite planning to ITU.
- Seeking agreement with ITU members by doing satellite coordination to get complete satellite coordination result.
- Pay cost recovery to ITU.
- Sending Res 49 (satellite launching information and others include manufacture of the satellite to ITU).
- Do negotiation with satellite manufacturer.
- Chose insurance.
- Chose satellite launcher.
- Notify satellite filing to ITU.
- Launching satellite to the orbit
Current Satellite Filing Process

CURRENT SATELLITE PROCESS

Satellite Plan and Preliminary Design (APIA): 
*Done by Satellite Operator and Government*

1. Filing Satellite Design
2. API Evaluation
3. API Submission to ITU
4. Reevaluated from ITU
5. Final Submission to ITU with ITU software program
6. Cost Recovery Payment
7. Coordination Request

Satellite Coordination: 
*Done by Satellite Operator and Government*

1. Potential Interference Solving
2. Negotiation Bilateral
3. Coordination Approach: Beam Isolation, Frequency Sharing, Cross Polar Isolation
5. The Real Battle of "Continue or Discontinue" Satellite Filing

Satellite Notification: 
*Done by Satellite Operator and Government*

1. Completed All Satellite Coordination Process
2. Res 49 Submission to ITU
3. Satellite Launching (include assurance)
4. Sending Notification to ITU
5. Cost Recovery Payment

Diagram:

- **GOVERNMENT RESPONSIBILITY**
- **SATELLITE OPERATOR RESPONSIBILITY**
- **MIXED**
- **DELIVERY SATELLITE CAPACITY TO PUBLIC**
- **SATELLITE OPERATOR RESPONSIBILITY**
Proposed Satellite Filing Process

**Satellite Process Proposal**

- **Satellite Plan and Preliminary Design (API/A):**
  1. Filing Satellite Design
  2. API Evaluation
  3. API Submission to ITU
  4. Reevaluated from ITU
  5. Final Submission to ITU with ITU software program
  6. Cost Recovery Payment
  7. Coordination Request

- **Satellite Coordination:**
  1. Potential Interference Solving
  2. Negotiation Bilateral
  3. Coordination Approach:
     - Beam Isolation, Frequency Sharing, Cross Polar Isolation
  4. Home and Away Satellite Coordination Process
  5. The Real Battle of “Continue or Discontinue”

- **Satellite Notification:**
  1. Completed All Satellite Coordination Process
  2. Res 49 Submission to ITU
  3. Satellite Launching (include assurance)
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**Time Line:**

- **Years:** 0 to 7

**Layers:**

- **Government Responsibility**
  - Layer One
  - Layer Two

- **Years:** 0 to 15

**Delivery Satellite Capacity to Public**
Two Layer Function Model

Satellite deployment model in Indonesia is developed by government investment budget that we called “layer one”. The whole processes should follow Radio Regulations was setted up by ITU. When “layer one” as a government function is completed and satellite capacity is ready be delivered to the users, then private companies, or government enterprises that already be selected by the government deliver that capacity.

The selection of the operators could be through an auction, or others of selection method. The function of private company or government enterprises delivery satellite capacity or satellite service to their customers its called “layer two”.

Satellite Business Cycle
Satellite Deployment Proposal in Indonesia
Government Perspective

- Certainty of satellite capacity to all users in Indonesia, mostly to unserved area.

- Indonesia will decrease the dependence of foreign satellite capacity in the future.

- Will make Indonesia as the shaft of maritime the world.

- Government budget that used for public service to provide satellite capacity will not be negative value because any budget for capital expenditure will be back again in the time period be setted up with the operators.
Operators Perspective

- Satellite operators will do a commercial business, so they will get a value from their activity.

- If one operator or more want to be a satellite operator, they must comply with all the requirements.

- They can make their own budget or collaborate with other operators as a consortium.
Conclusion

1. Government can make a strategy to provide public service to public.
2. Complexity of the satellite filing process, fully regulated by ITU, upfront budget, there was supply and demand gap condition.
3. It is important to take a new strategy to fulfill national satellite capacity.
4. Two layer model is one of strategy of Indonesia to fulfill satellite capacity.
5. Government Function such as, satellite plan and design, satellite coordination, satellite notification, satellite launching, and satellite control.
6. Satellite operators deliver satellite capacity to users.
7. Layer one function will be done by a special Government entity.
8. Layer two as function of those operators that eligible by selection of Government.
Thank You

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