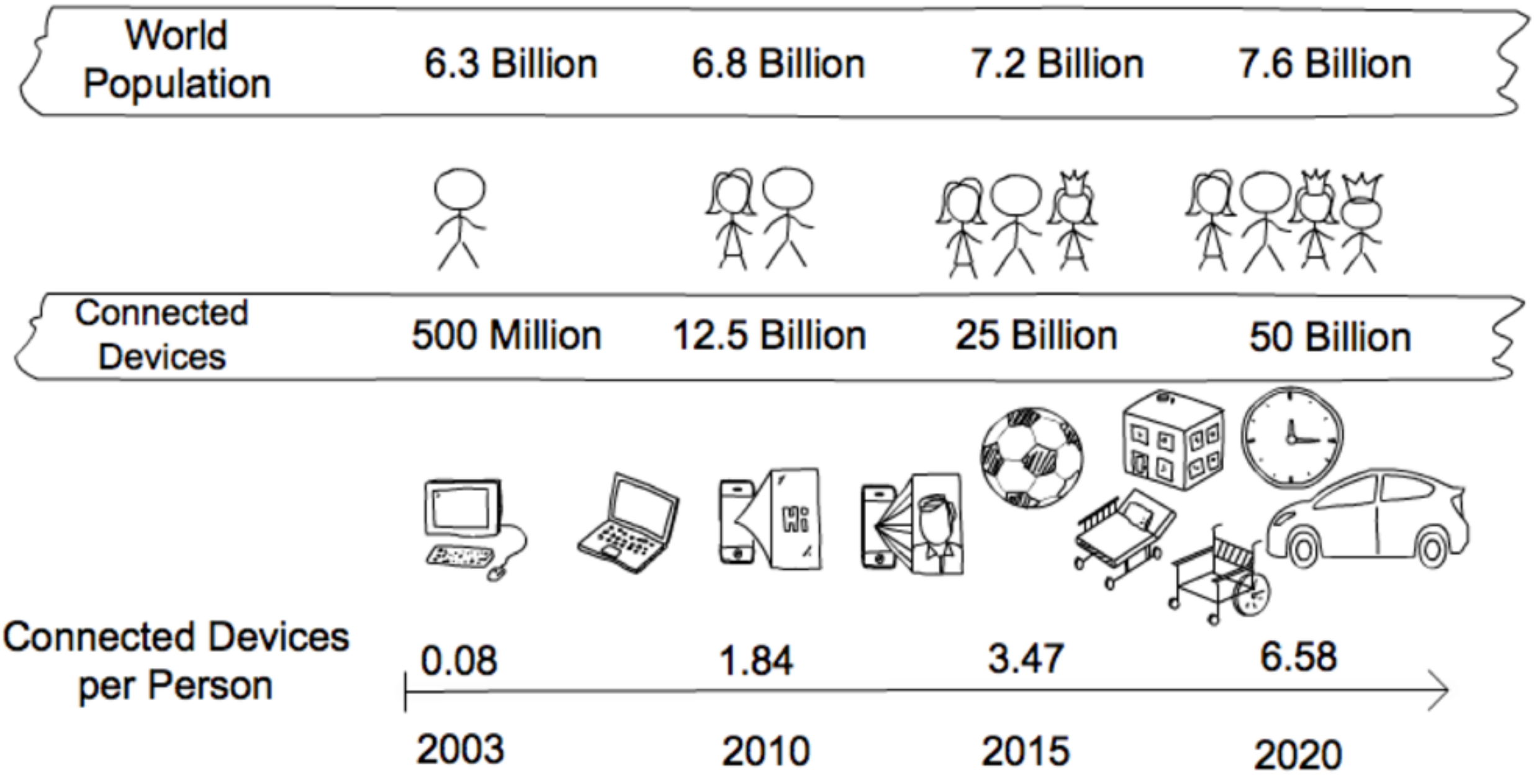
Wireless Communication with Machine Learning

Ade Irawan, Ph.D.

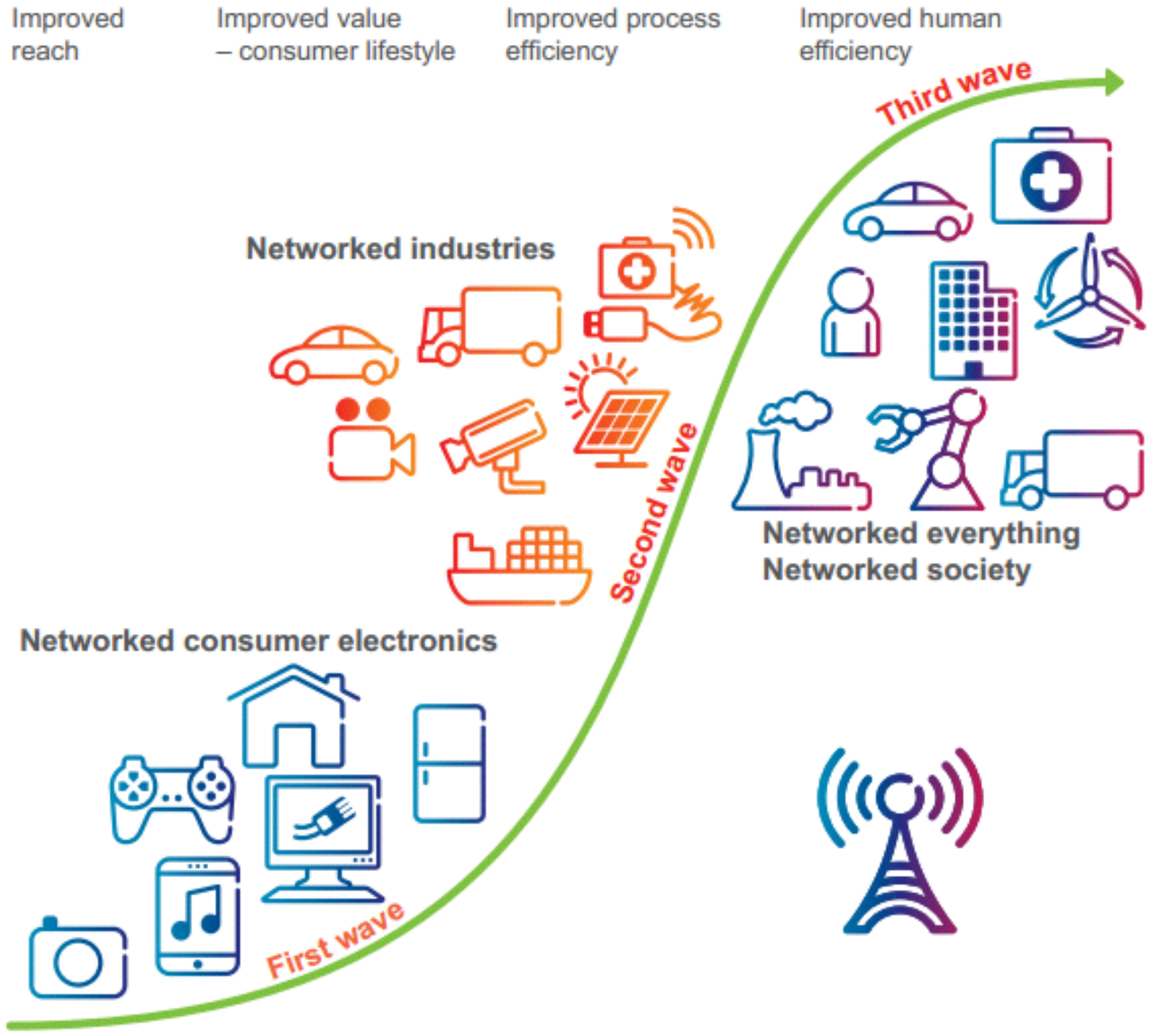
Presented at BINUS University
18 May 2018

50 Miliar Perangkat Terhubung di Tahun 2020



source : Cisco, April 2011

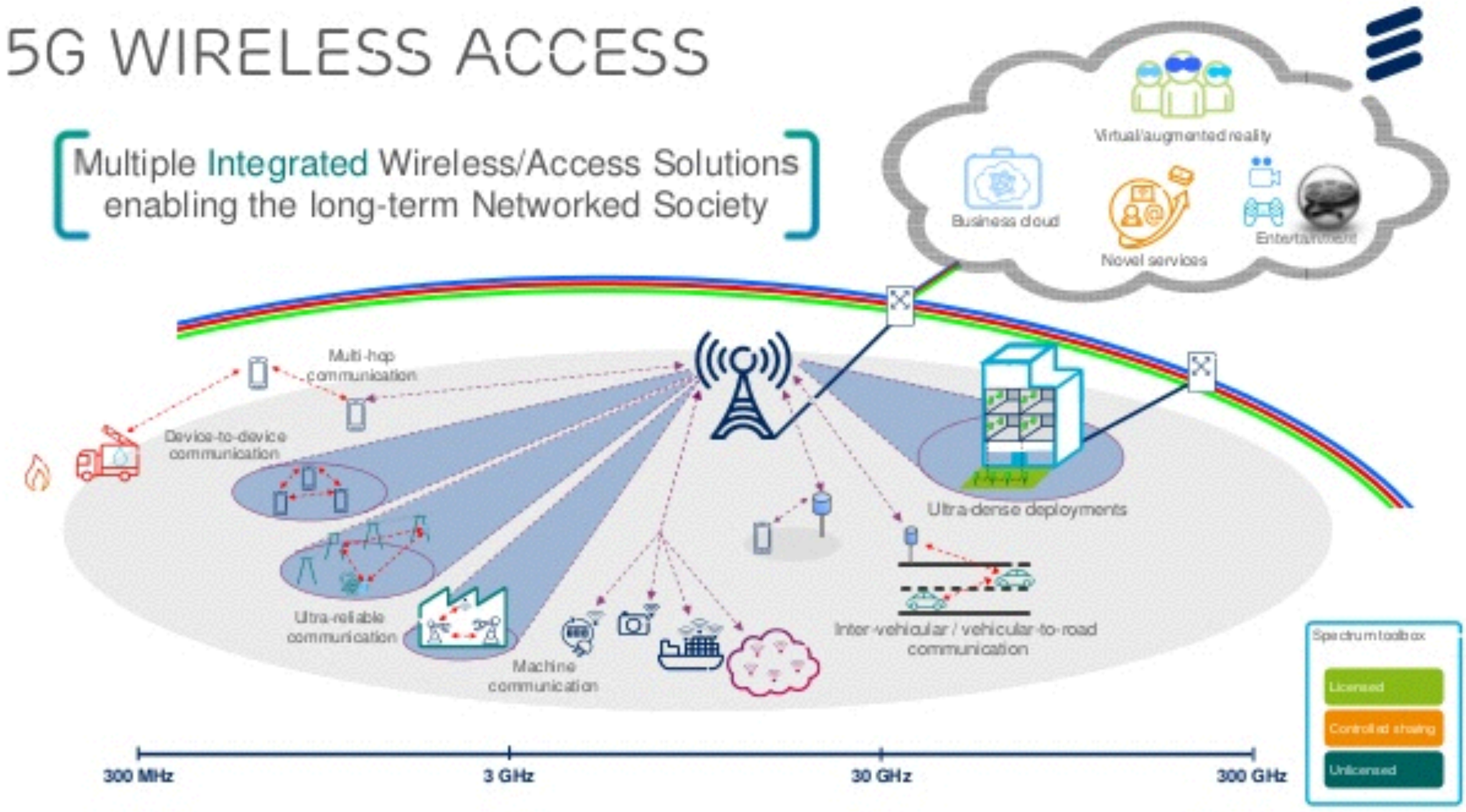
Perkembangan Aplikasi dari Perangkat yang Terhubung



The three waves of connected device development.

source : http://www.rcrwireless.com/20120627/devices/m2m-revenues-expected-to-reach-92-billion-in-latam-by-2020-2

5G untuk Komunikasi Masif



source : Ericsson

Outline

- Evolusi Komunikasi Nirkabel
- Teknologi 5G
- Aplikasi dan/atau Manfaat dari 5G
- Peranan Machine Learning di Komunikasi Nirkabel
- Kesimpulan

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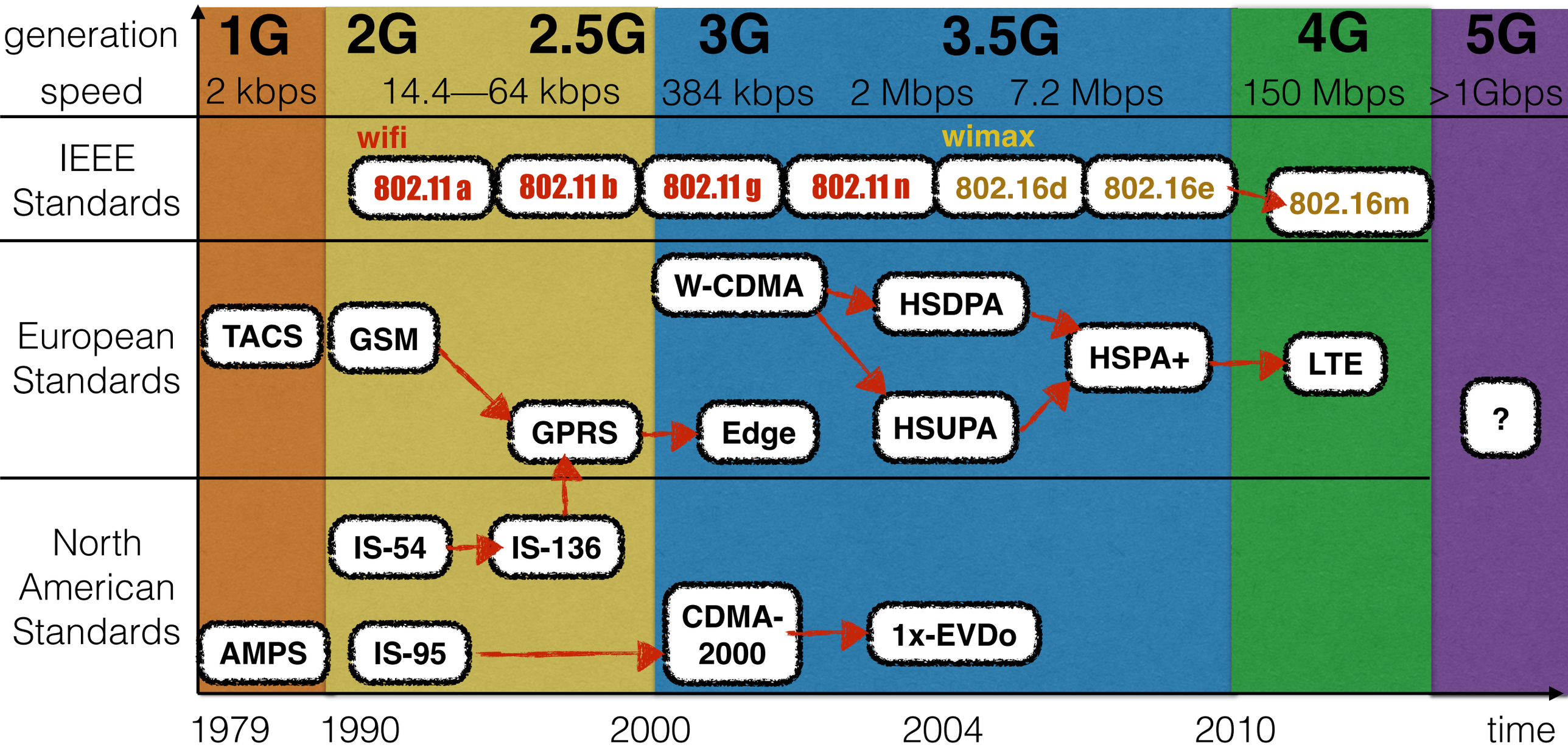
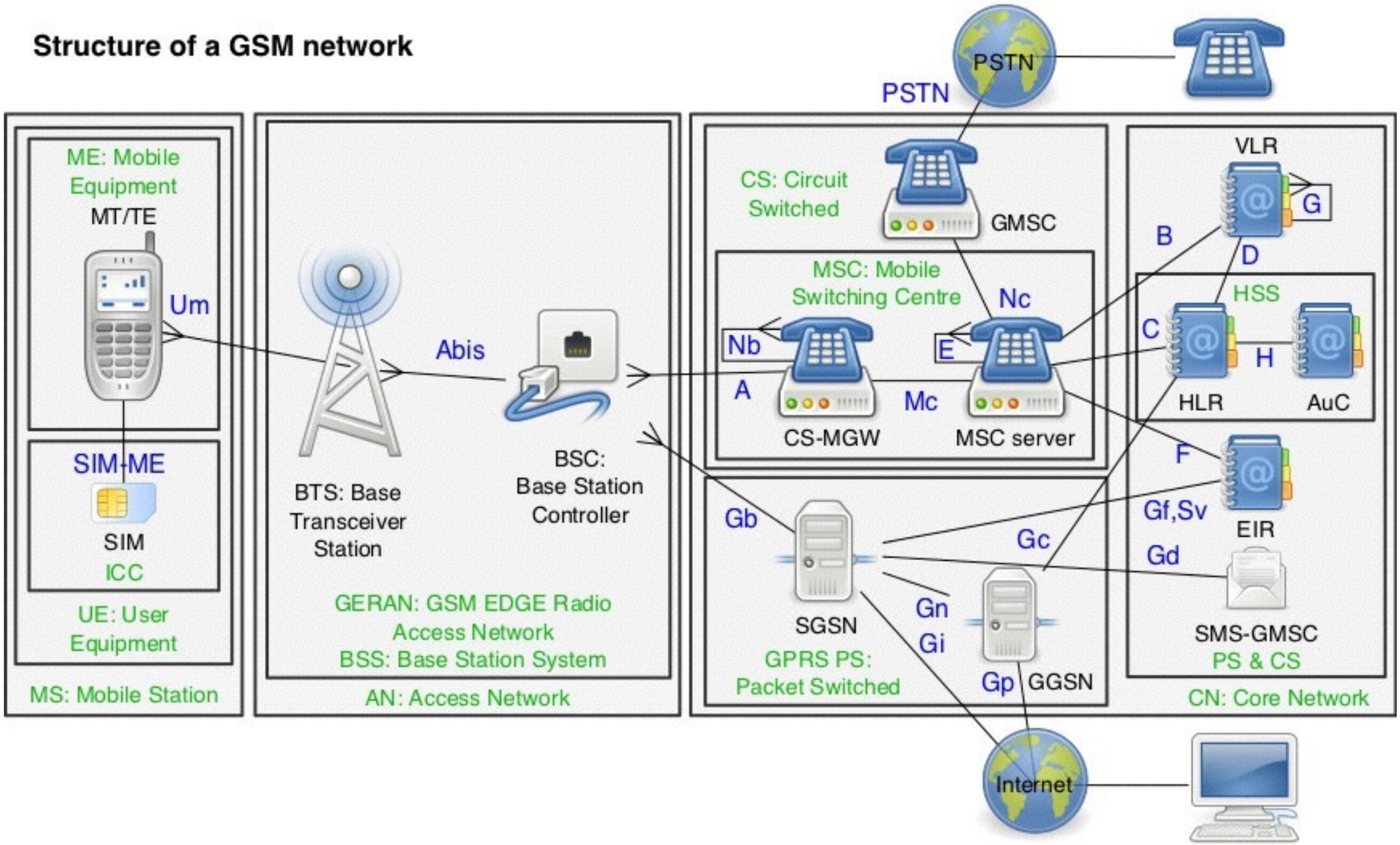
1G, 2G, 3G, 4G, 5G ?

iPhone
3G

Evolusi Komunikasi Nirkabel



GSM



source : https://en.wikipedia.org/wiki/GSM#/media/File:Gsm_structures.svg

3GPP

- 3rd Generation Partnership Project (3GPP)
- Kolaborasi dari beberapa grup asosiasi telekomunikasi dunia (dari Asia, Eropa, Amerika), biasa disebut Organizational Partners :
    1. Association of Radio Industries and Businesses (ARIB) : **Japan**
    2. Alliance for Telecommunications Industry Solutions (ATIS) : **USA**
    3. China Communications Standards Association (CCSA) : **China**
    4. European Telecommunications Standards Institute (ETSI) : **Europe** —> GSM
    5. Telecommunications Technology Association (TTA) : **Korea**
    6. Telecommunication Technology Committee (TTC) : **Japan**
    7. Telecommunications Standards Development Society India (TSDSI) : **India**
- Standardisasi:
    - 2G+2.5G: (evolved) GSM, GPRS, EDGE
    - 3G based on UMTS standard by ITU (Japan: FOMA) : W-CDMA, HSDPA, HSUPA, HSPA+
    - 4G : LTE, LTE-Advanced

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5G-PPP

- Inisiasi : July 2012

- February 2013 dalam acara Mobile World Congress di Barcelona, beberapa perusahaan dan instansi ikut serta (partner)

5G-PPP Target

- Providing 1000 times **higher wireless area capacity** and more varied service capabilities compared to 2010

- **Saving** up to 90% of **energy** per service provided**.** The main focus will be in mobile communication networks where the dominating energy consumption comes from the radio access network

- **Reducing the average service creation time cycle** from 90 hours to 90 minutes

- **Creating a secure, reliable and dependable Internet** with a “zero perceived” downtime for services provision

- **Facilitating very dense deployments of wireless communication links** to connect over 7 trillion wireless devices serving over 7 billion people

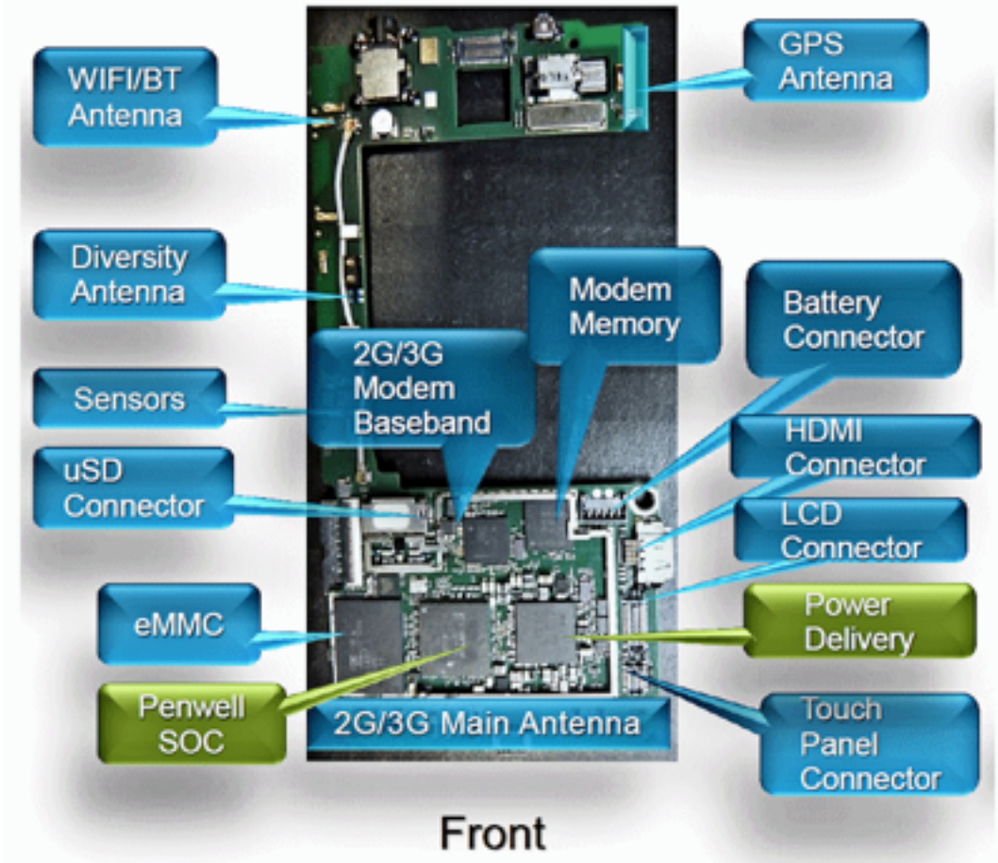
- Enabling **advanced User controlled privacy**

source : https://5g-ppp.eu/history/

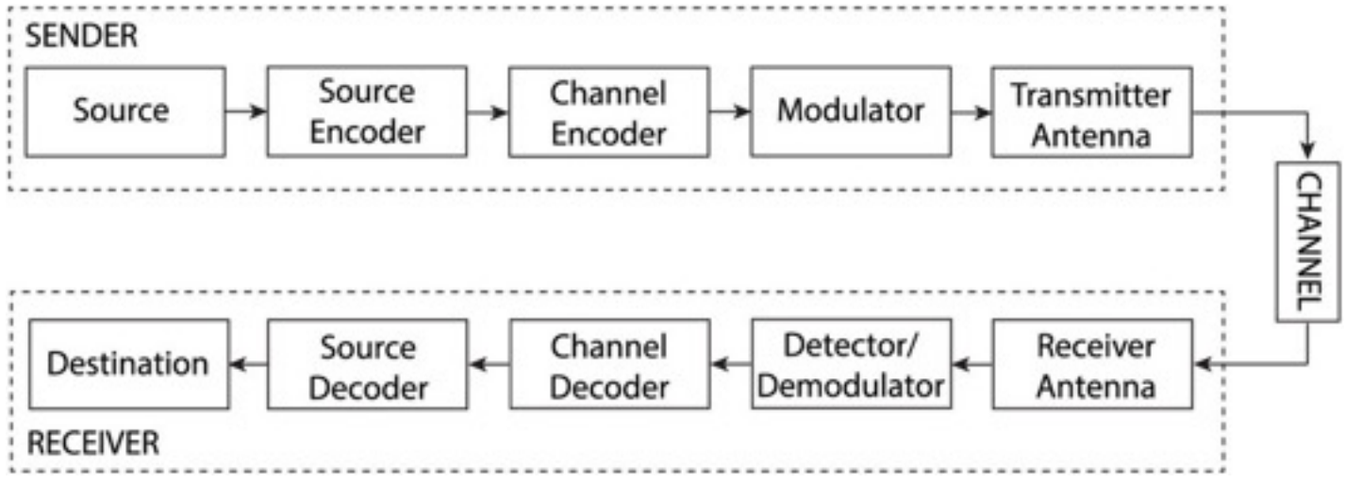
5G Requirements

- High capacity (data rates) and coverage
- Low device energy consumption
- Low latency
- Reliable
- Support very dense communication links
- Secure

Systems



model



Beberapa Keunggulan **5G**

1. *New realities*
   mendukung *augmented reality* dan *virtual reality* menjadi *mainstream*.
2. *High speed download*
   4G: 150 *Mbps*
   5G: 1 *Gbps —….*
3. *Lightning-fast response*
   - throughput yang besar : banyak *bit* data per detik,
   - lagging yang kecil : jeda yang singkat sebelum *bit* pertama muncul.
   - perbandingan saat *video streaming* :
   4G : butuh waktu jeda 15 sampai 25 milidetik,
   5G : butuhkan waktu jeda 1 milidetik.

NTT Docomo Vision 2020

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Distance Learning

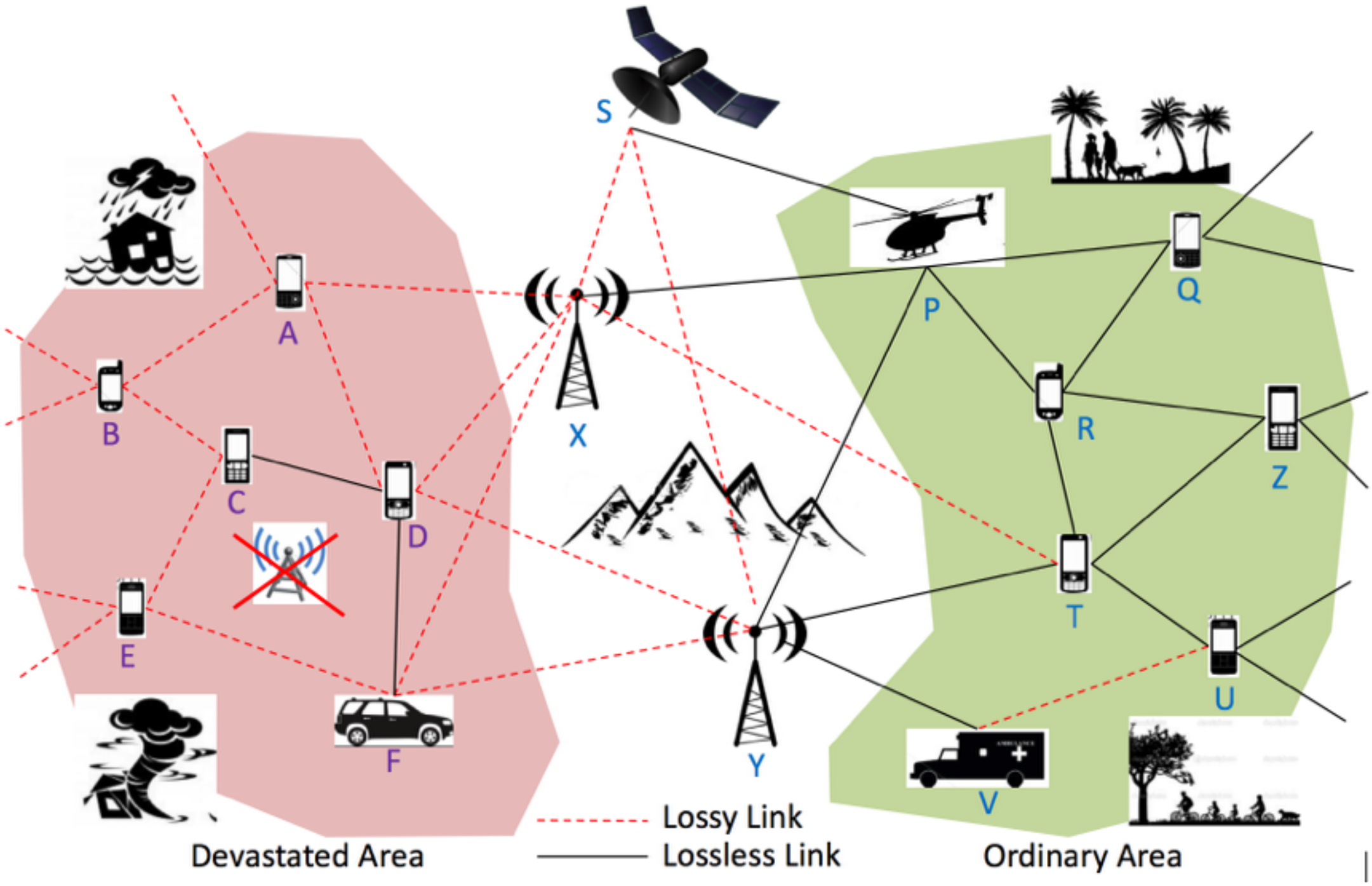
- Massive Online Open Courses (MOOC)
- Harapan : Tidak ada daerah tertinggal

Smart City/Village with Internet of Things (IoT)

source : http://ajw.asahi.com/article/business/AJ201407200009

Perangkat Kesehatan Masa Depan

Penanggulangan Bencana



http://www.ict-rescue.eu/

Lossy Forwarding Technique for Parallel Multihop-Multirelay Systems

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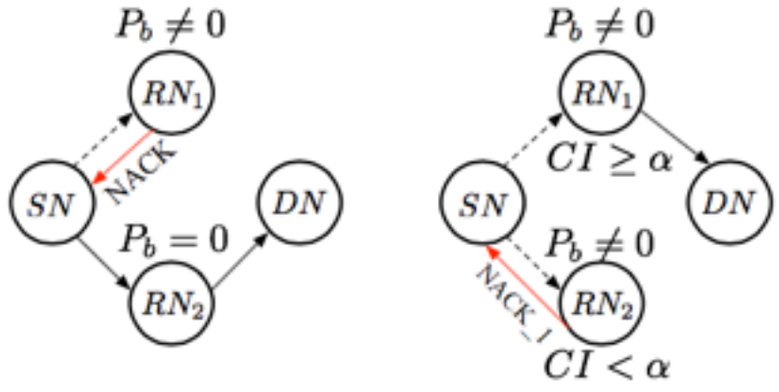
***Abstract*—This paper proposes a Partial Hybrid Automatic Repeat reQuest (P-HARQ) scheme where the relaying nodes select either forwarding the erroneous packets or requesting retransmission. In contrast to the conventional technique where the erroneous packets is always discarded, the packets found to have errors after decoding are interleaved, re-encoded, and forwarded if relay selects the forwarding mode. This technique is refer to as lossy forwarding. In this paper, the mode selection (either forwarding or requesting retransmission) is based on the confidence indicator (CI). Since the channels are assumed to suffer from block Rayleigh fading, the CI is calculated via online mutual information measurements, block-by-block. Results of computer simulations conducted to confirm the superiority of the proposed P-HARQ technique in terms of bit-error-rate, packet-error-rate and throughput performances in parallel multihop wireless multirelaying systems, are presented.**



(a) Conventional HARQ (b) Proposed HARQ

Fig. 1. Multihop relaying comparison between the conventional and the proposed HARQ.

RESCUE

SEVENTH FRAMEWORK PROGRAMME

IEEE TVT - 2018

Feedback-Assisted Correlated Packet Transmission with A Helper

Ade Irawan, *Member, IEEE,* and Tad Matsumoto, *Fellow, IEEE*

***Abstract*—In this paper, we analyze the impact of source correlation on the diversity and coding gains of a retransmission system where we aim to recover M erroneously received packets only by transmitting one helper packet utilizing the source correlation among the packets. This system is referred to as M-in-1 helper transmission. The helper packet is constructed simply by taking binary exclusive-OR of the M erroneously received information packets, notified via the feedback channel. To identify the trade-off between source correlation and performance gain due to coding and diversity, we start our investigation with in-depth analyses on rate regions and outage probabilities with $M = \{2, 3\}$. We also evaluate the influence of unequal power and/or redundancy allocations between the helper and information packets. Finally, we provide the analytical results on achievable diversity order with arbitrary *integer* values of M. It is shown that M-in-1 helper transmission can always achieve M-th order diversity. Furthermore, $(M+1)$-th order diversity can be achieved with M being odd when the source correlation is very high; however, it cannot be achieved with M being even.**

***Index Terms*—outage probability, admissible rate region, source correlation, feedback, HARQ, helper**

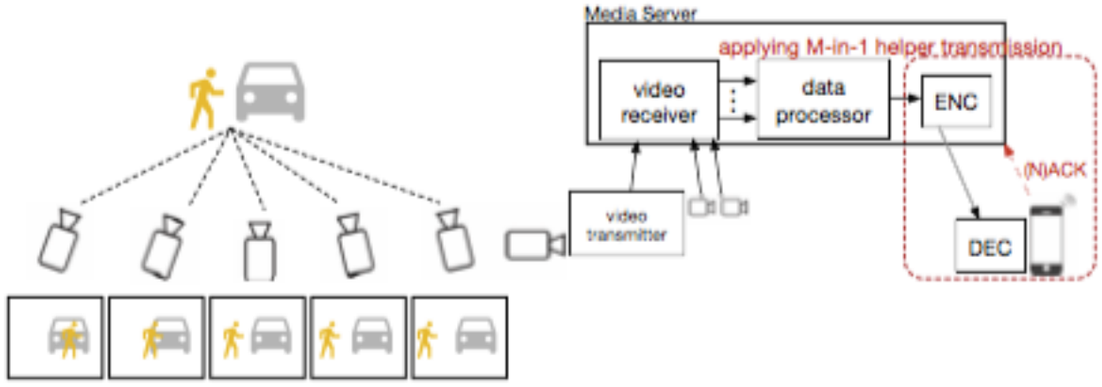


Fig. 1: Media server collects and processes the correlated packets.

In practice, Long Term Evolution (LTE) adopts H.265—High Efficiency Video Coding (HEVC) [4] to achieve high video compression. It is enabled by removing *temporal* data correlations within a picture and between pictures of a video sequence, using intra and inter prediction techniques, respectively [5]. The intra prediction assumes that the visual property of a picture region is similar to that

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Kesimpulan

- Teknologi *5G and beyond* akan memberikan pengalaman layanan telekomunikasi yang lebih luas dan lebih cepat dari yang sudah ada kepada manusia dan mesin, kapan saja dan di mana saja.

- *Machine Learning* akan banyak dimanfaatkan untuk mendukung teknologi diatas 5G, terutama berperan untuk: *self-healing, self-organizing, self-optimization*.

- Dengan begitu banyaknya manfaat yang bisa didatangkan oleh generasi terbaru komunikasi nirkabel, sudah saatnya bagi Indonesia untuk ikut serta dalam pengembangan teknologi ini untuk *the next generation*, sehingga tidak hanya sebagai “pasar" tapi juga sebagai “pencipta” dan “pemasok” teknologi.

Terima Kasih