PATRIOT-Net: Prevention and Recovery Networks for Natural Disasters based on IoT

-Exploiting Deep Learning Algorithm and 5G Communications-

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Jakarta, 27 November 2018

Academic Life: Satisfying Sinusoidal Wave


1

2

3

1996–2000 : B. Eng., Institut Teknologi Bandung (ITB)
2000–2002 : PT. Astragraphia Information Technology, Jakarta
2002–2003 : Tokyo Institute of Techology
2003–2005 : M. Eng, Nara Inst. of Science and Tech. (NAIST)
2005–2008 : Dr. Eng., Nara Inst. of Science and Tech. (NAIST)
2008–2016 : Asst. Prof., Japan Adv. Inst. of Sci. and Tech. (JAIST)
2016–Now : Asct. Prof., School of Electrical Eng., Telkom University

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[1] Best Student Paper Award, IEEE RWS'06, California, USA, Jan 2006.

[2] Master and PhD Thesis are adopted by ITU-R Standard for Satellite Communication in the world, 2011.

[3] Achmad Bakrie Award 2014.

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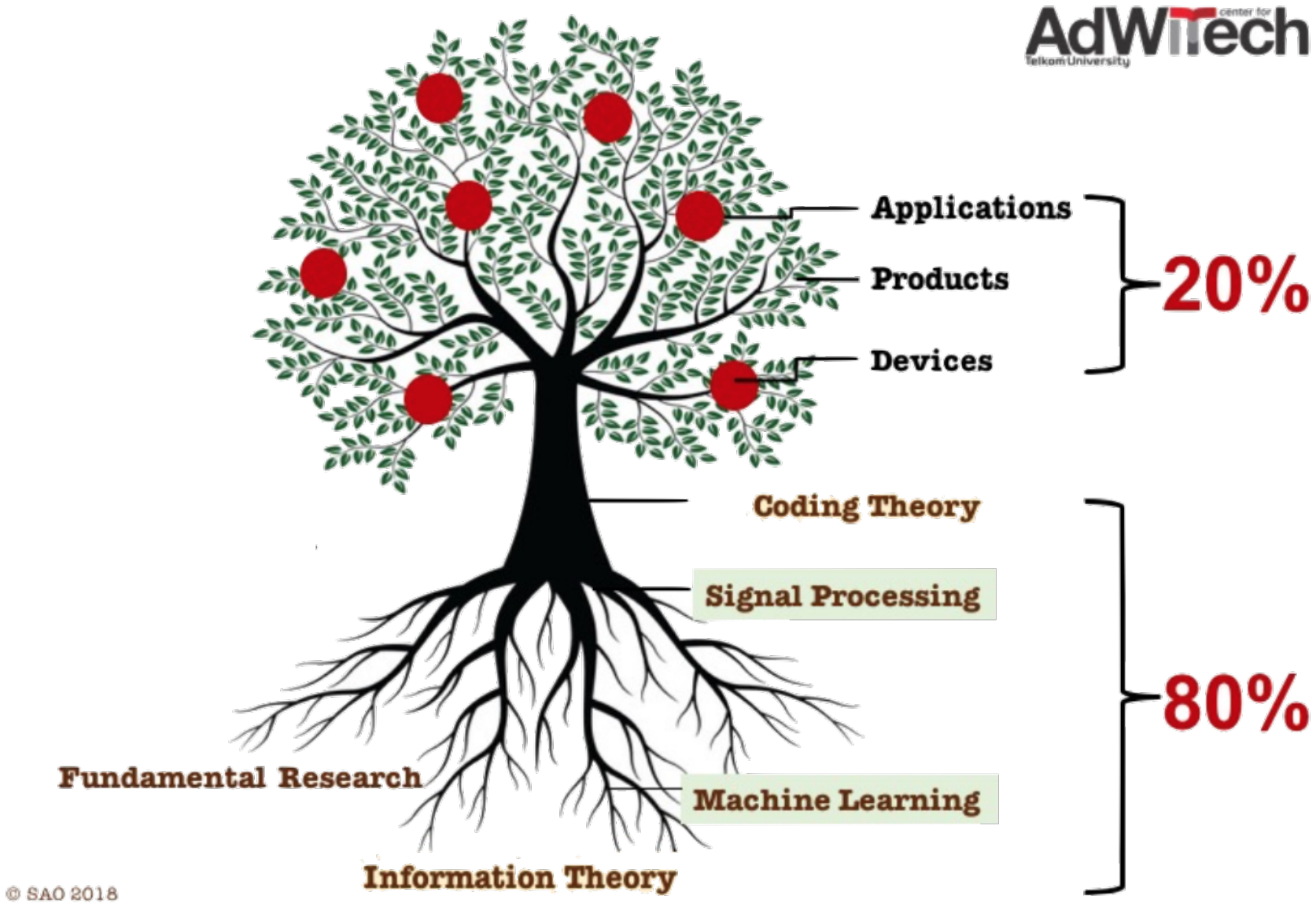
Center for Advanced Wireless Technologies



Recent 5G and PPDR Activities in AWG-24, Bangkok

- Chairman at Asia Pacific Telecommunity Wireless Group (AWG)-24, Bangkok, Thailand, 17-21 Sept. 2018.

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Outline

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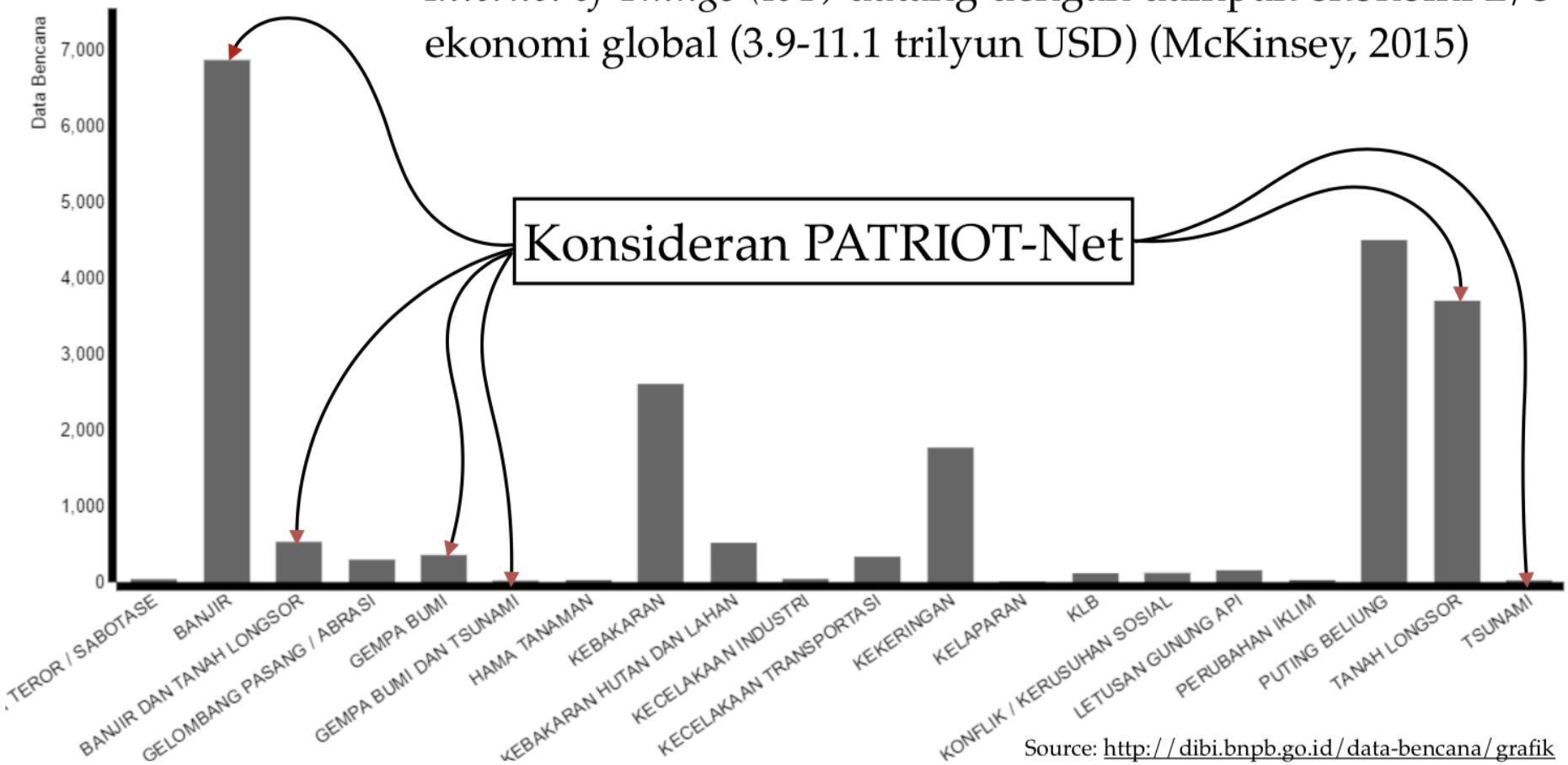
The Urgent of PPDR Technologies

- *Internet of Things (IoT)* datang dengan dampak ekonomi 2/3 ekonomi global (3.9-11.1 trilyun USD) (McKinsey, 2015)



Source: http://dibi.bnpb.go.id/data-bencana/grafik

5G Massive Machine-Type Communications for PPDR

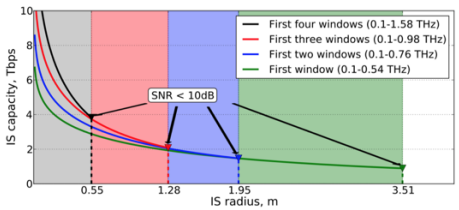
Antenna Design for 5G and 6G

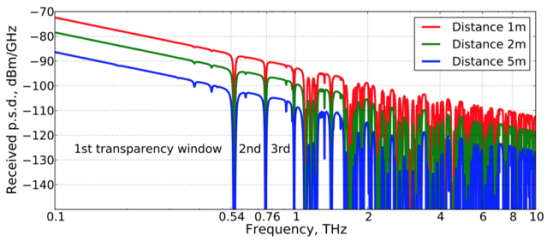
Massive MIMO

128 QAM,
512 QAM,
Turbo Modulations

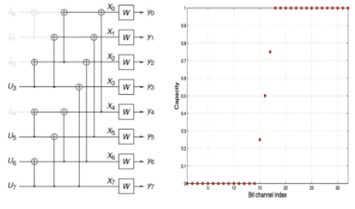
Tel-U 5G and 6G Channel Model

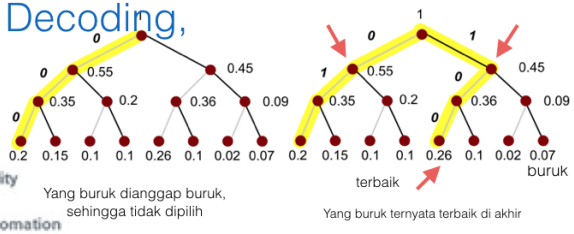
$$C = n \cdot B \log_2 \left(1 + R \cdot M \cdot \frac{|H|^2 E_b}{N_0}\right)$$

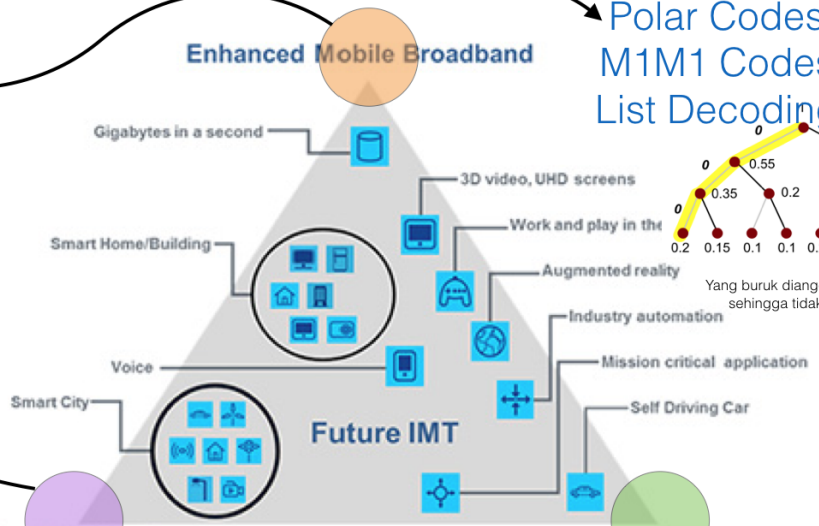


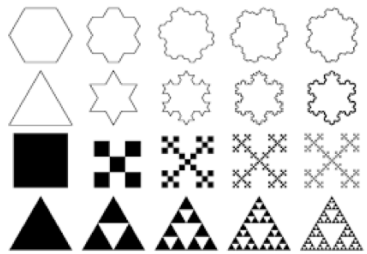


Polar Codes,
M1M1 Codes,
List Decoding,

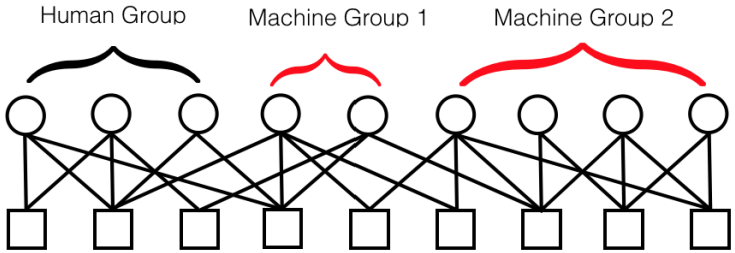








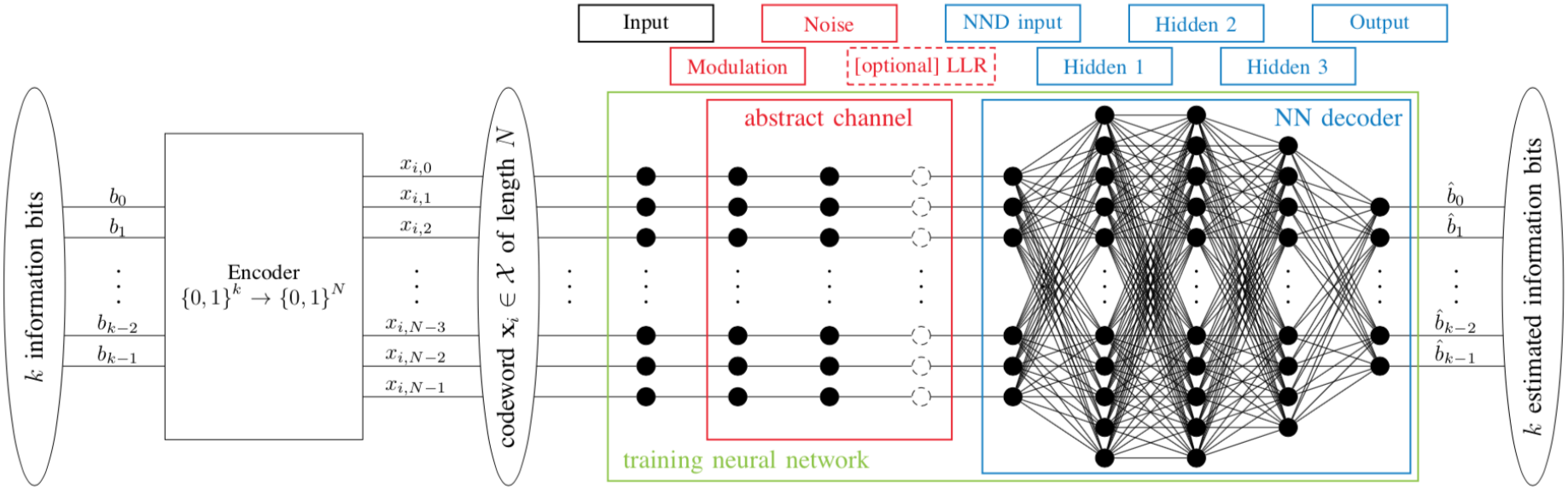
- Indonesia NB-IoT/BB-IoT
- Indonesia IoT for Natural Disaster
- Coded Random Access/SDMA
- Humanity-5G: Prioritising Human
- Raptor-Structured Networks
- Information Theoretic Secure Networks
- Beamforming



- Fractal of Polar Codes
- Polar Multiple Access

$$\Omega(x) = \exp\left(-\left(\frac{G_1}{R_1} + \frac{G_2}{R_2} + \frac{G_3}{R_3}\right)(1-x)\right)$$

Deep Learning for Disaster Prevention and Recovery



- Sigmoid function and Rectified Linear unit (ReLU):

$$g_{sigmoid}(z) = \frac{1}{1+e^{-z}}; \quad g_{relu} = \max\{0, z\}. \tag{1}$$

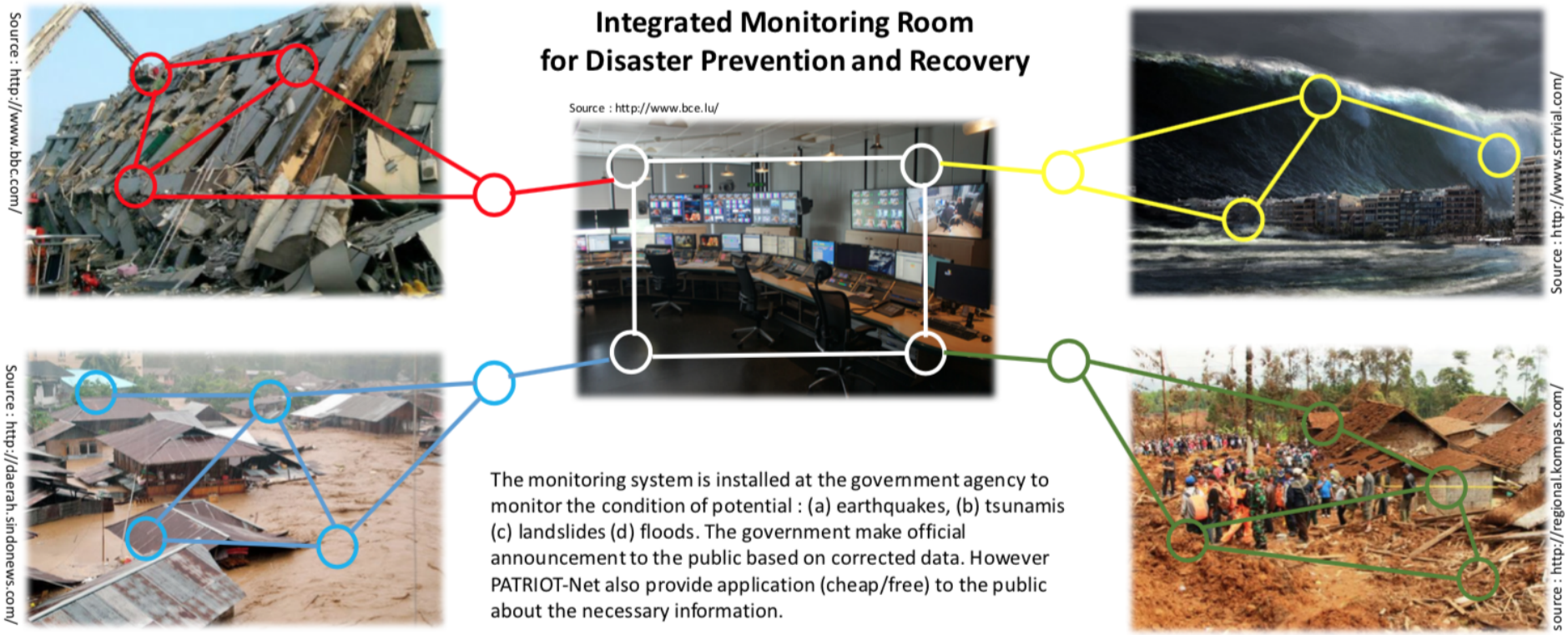
- Input-output mapping and depth L of parameter θ (v: input, w: output):

$$\mathbf{w} = \mathbf{f}(\mathbf{v};\theta) = \mathbf{f}^{(\mathbf{L-1})}\left(\mathbf{f}^{(\mathbf{L-2})}\left(\ldots\left(\mathbf{f}^{\mathbf{0}}(\mathbf{v})\right)\right)\right) \tag{2}$$

[3] Tobias Gruber, Sebastian Cammerer, Jakob Hoydis, and Stephan ten Brink, "On Deep Learning-Based Channel Decoding," ArXiv, Jan. 2017.

4-in-1: Single Technology for Multiple Disasters (1/2)

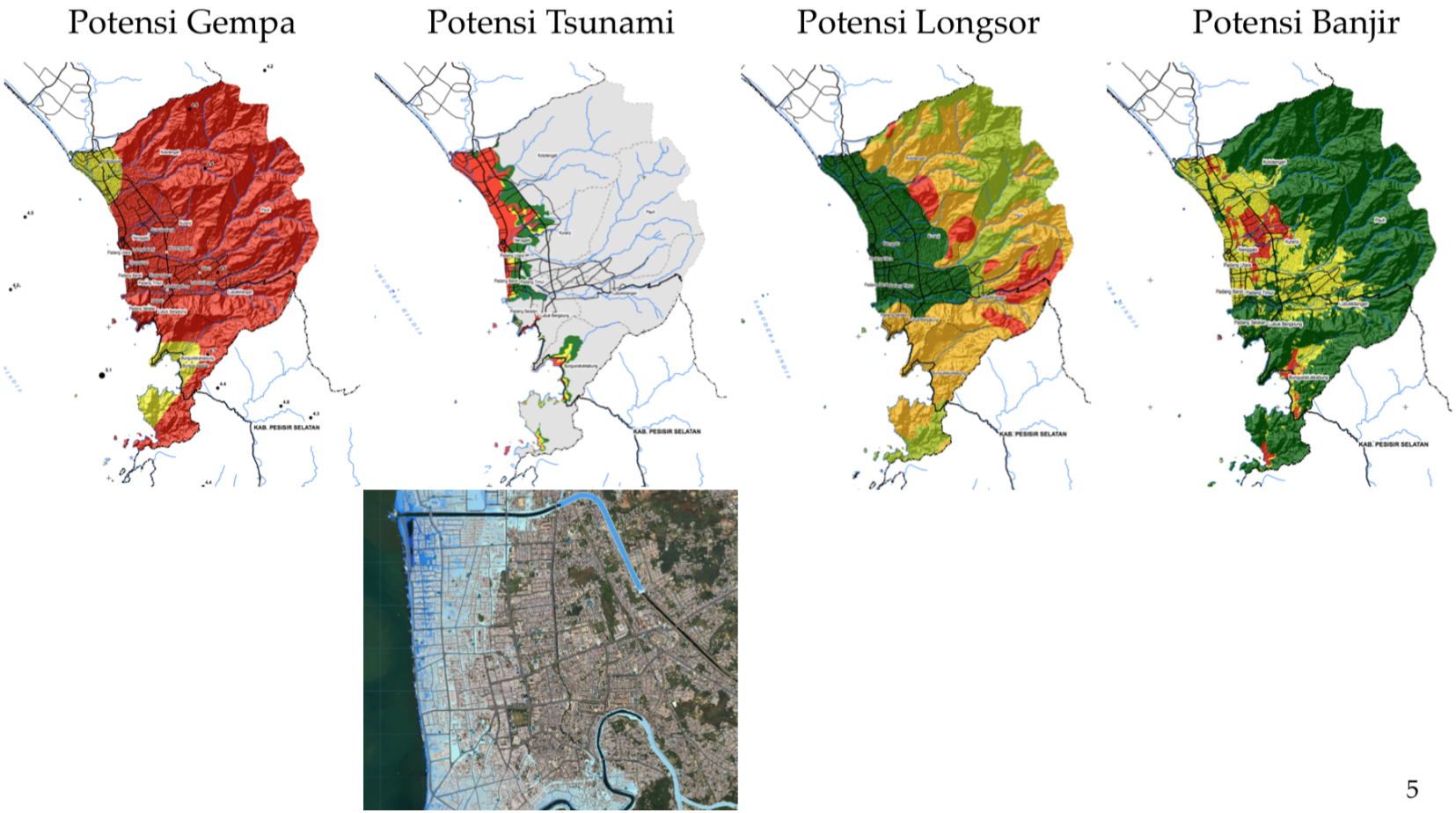
- Prevention: Theoretical Limit of Multiterminal (Networks)
- Network Recovery: Mobile Cognitive Radio Base Station (MCRBS)
- Massive Connections: Unifications of Several Disaster Sensings



[2] K. Anwar, "PATRIOT-Net", LPDP-RISPRO, October 2016.

4-in-1: Padang City, Indonesia (First Year Trial, 2019)

The map of 4 disasters: (i) Earthquake, (2) Tsunami, (3) Landslide, (4) Flooding monitored by the PATRIOT-Net.



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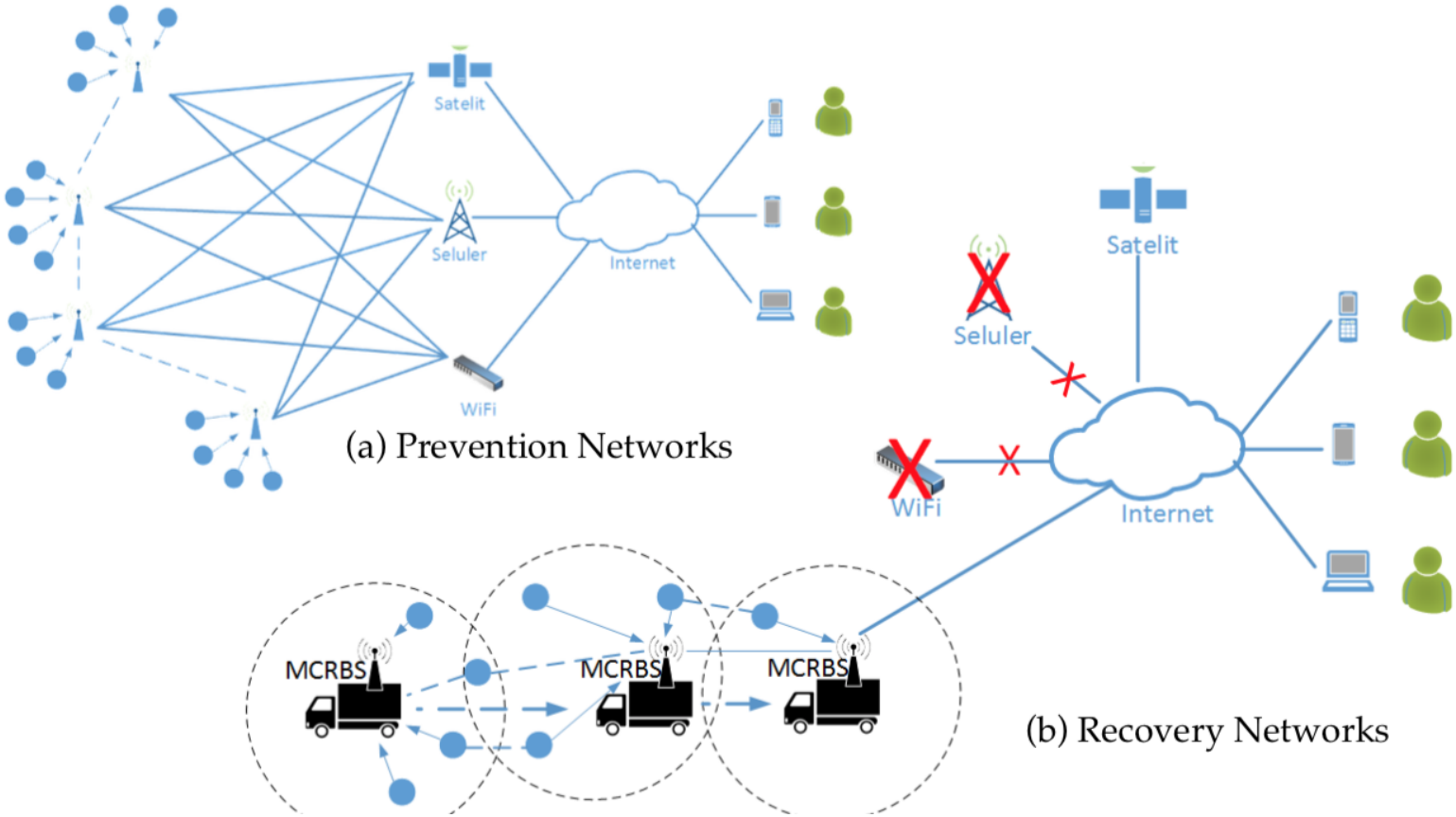
[2] K. Anwar, "PATRIOT-Net", LPDP-RISPRO, October 2016.

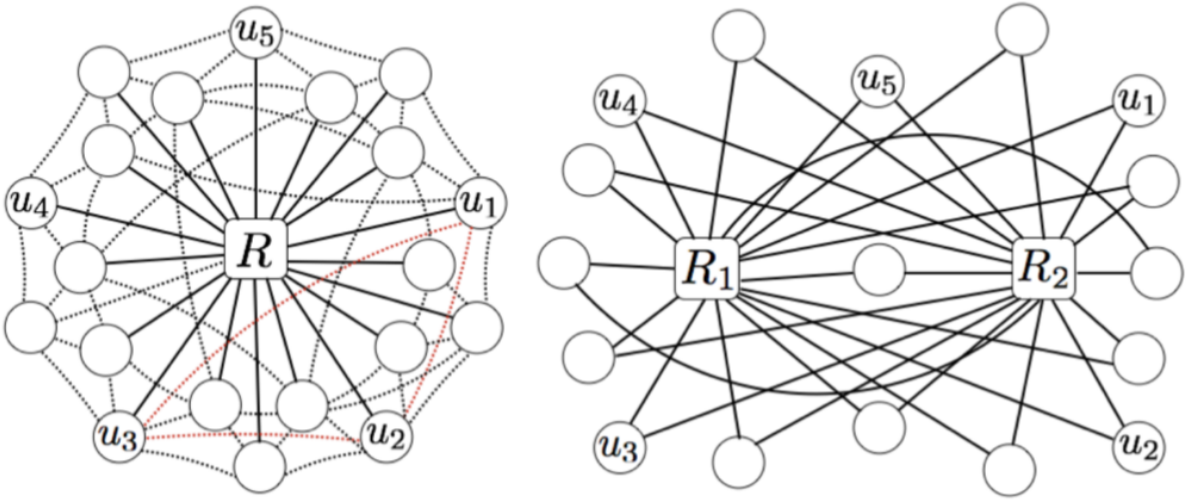
The Proposed PATRIOT-Network



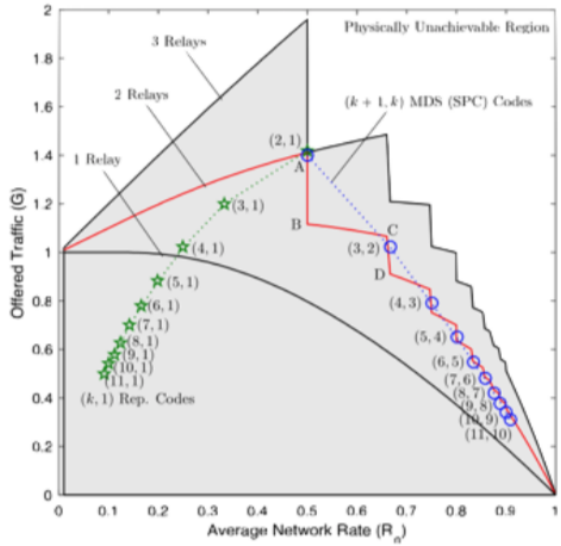
- Prevention: Collect information from massive number of sensors.
- Recovery: Some Mobile cognitive radio base station (MCRBS) helping the victims by establishing communications networks (voice and data).

K. Anwar, PATRIOT-Net, LPDP-RISPRO, 2018–2021.

Fundamental Theorem for The PATRIOT-Net



Source: K. Anwar, 2016.



Source: K. Anwar, 2016.

Theoretical Limit: Single Relay

$$R + \frac{R}{G} e^{-\frac{G}{R}} - \frac{R}{G} \leq 0.$$

Theoretical Limit: Multiple Relays

$$\frac{R}{1+QR} + \left(\frac{R}{G}\right) e^{-\frac{G}{R}} - \frac{R}{G} < 0,$$

[3] K. Anwar "Graph-based Decoding for High-Dense Vehicular Multiway Multirelay Networks", IEEE Vehicular Technology Conference (VTC2016-Spring), Nanjing, China, May 2016.

[4] K. Anwar, "High-Dense Multiway Multirelay Networks Exploiting Direct Links as Side Information", IEEE Internationa Conference on Communications (ICC2016), Kuala Lumpur, Malaysia, May 2016.

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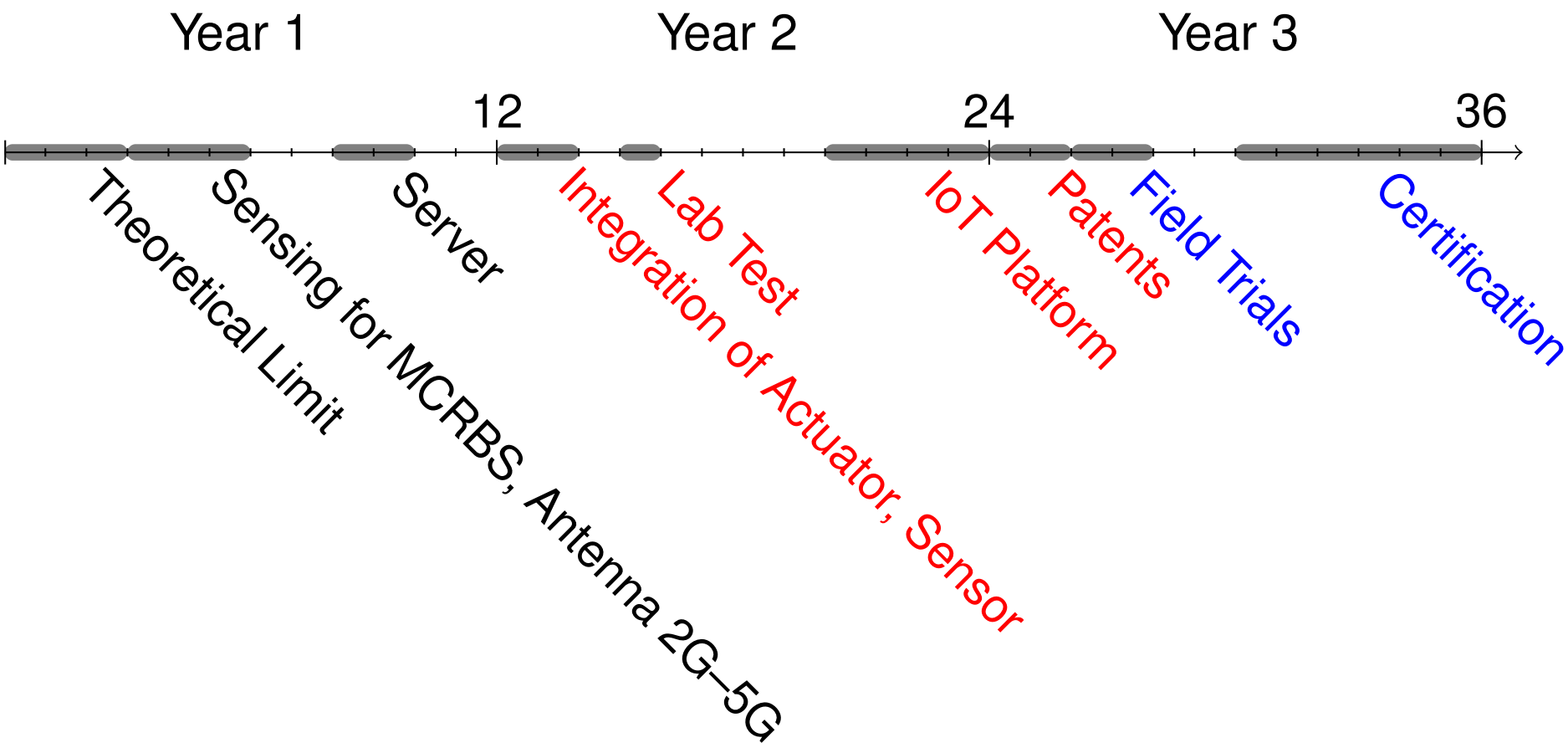
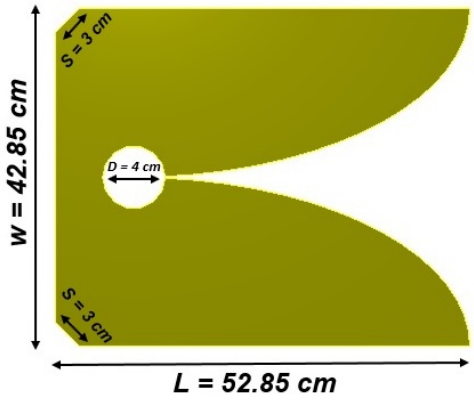
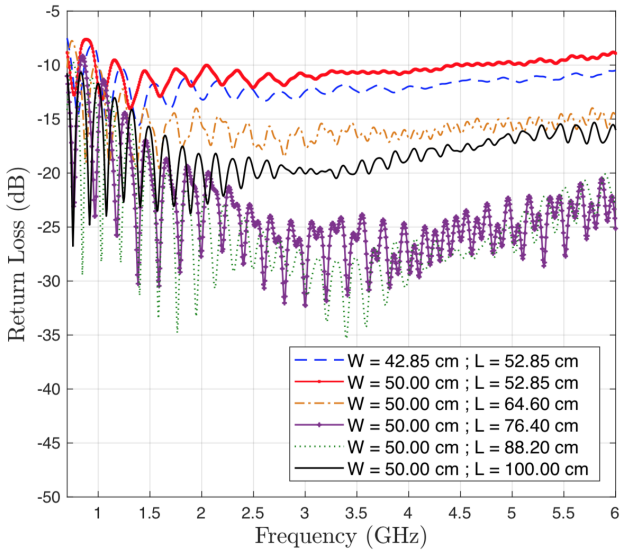
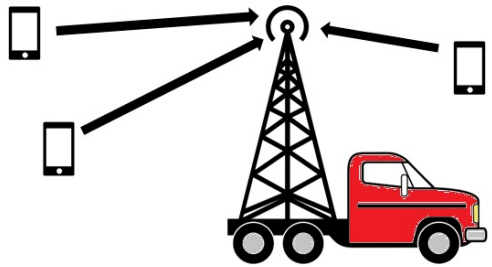
Roadmap of PATRIOT-Net for 3 Years



Prelim. Result 1: Multi-generations 2G–5G Antenna



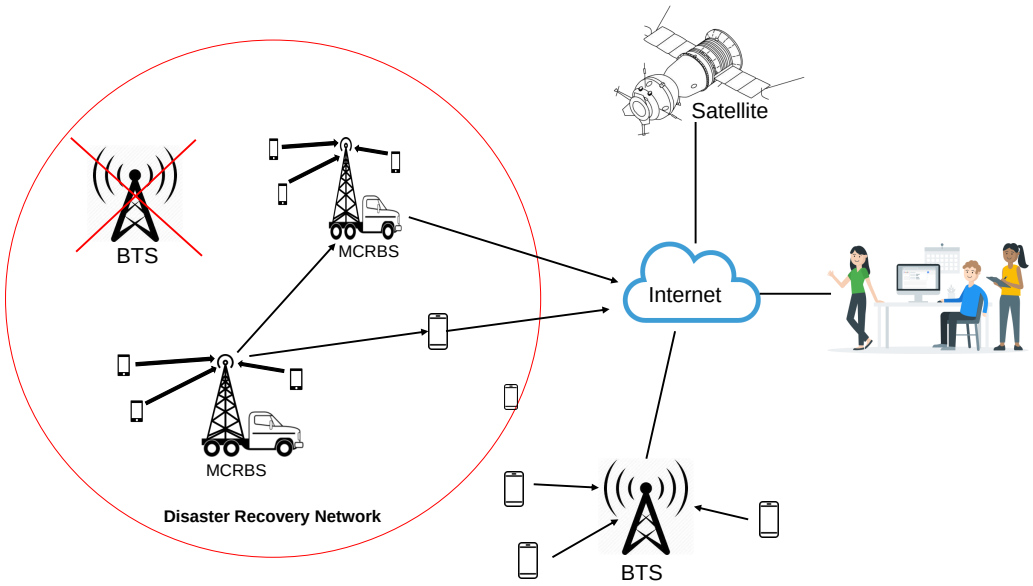


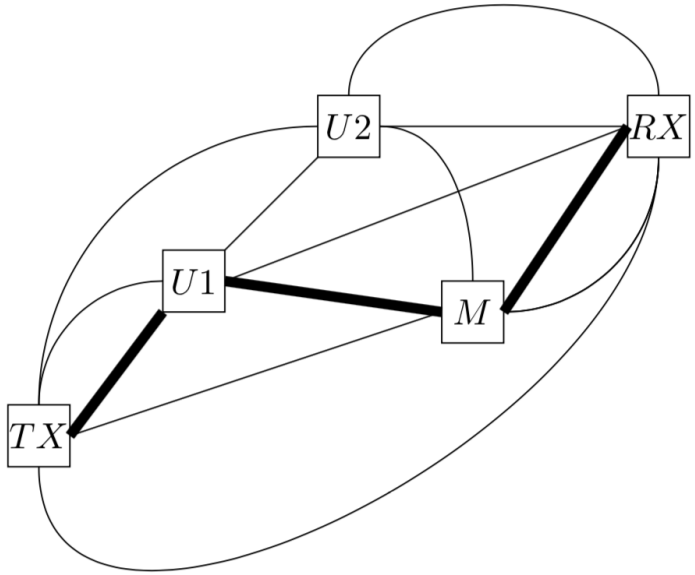


- The antenna can serve simultaneously multiple generations 2G, 3G, 4G, and 5G (below 6 GHz).

[1] Dammar Adi Sujiansyah, Budi Syihabuddin, Khoirul Anwar, and Nachwan Mufti Adriansyah, ”Antenna Design for Multi-generation of 2G5G for Rural Area Wireless Communications”, the International Conference on ICT for Rural Development 2018, October 1718, 2018.

Preliminary Results 2: Routing Algorithm (1/2)

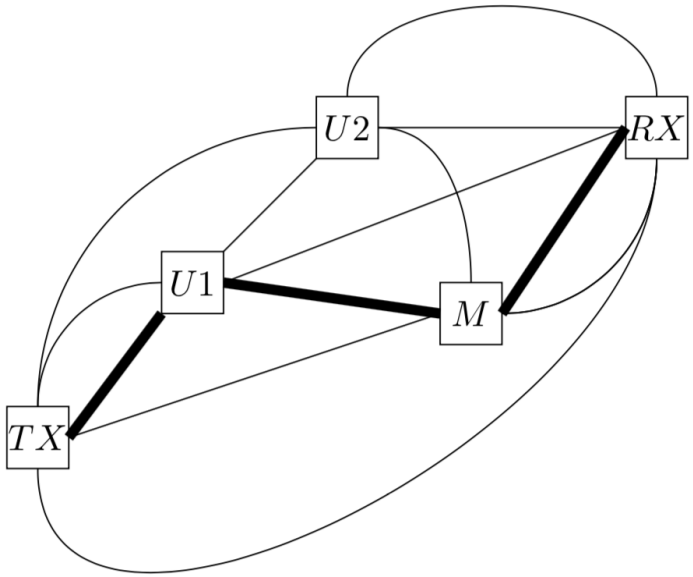


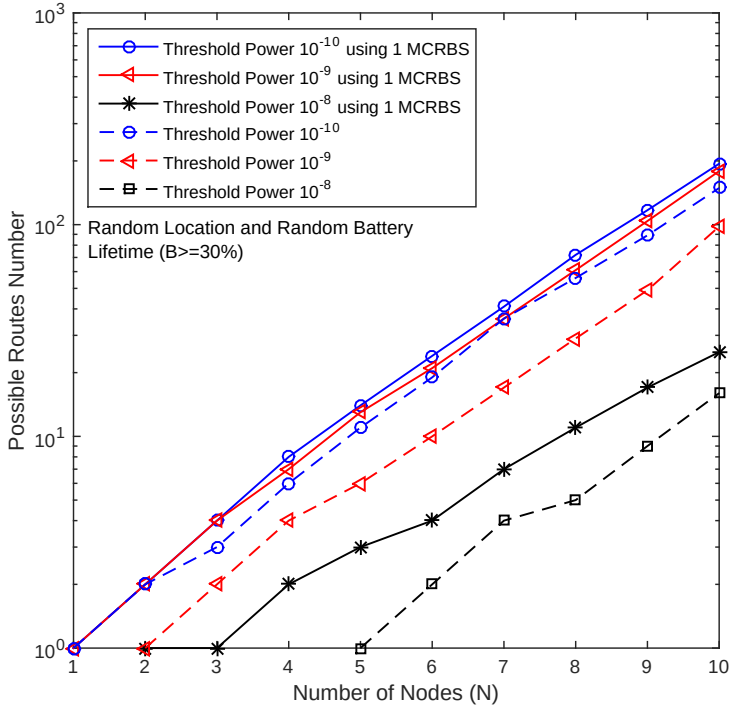


- M is MCRBS; U_1, U_2 are devices of victims helping communication of TX to RX.
- The number of possible routes is $2^3 = 8$.
- The total number of route is 2^N, with N being the total nodes helping the communications.

[5]. Siti Hartinah, Hario Prakoso, and Khoirul Anwar, Routing of Mobile Cognitive Radio Base Station for Disaster Recovery Networks, IEEE 2018 International Conference on Electrical Engineering and Informatics (ICELTICs), Banda Aceh, Indonesia, September 1920, 2018.

Preliminary Results 2: Routing Algorithm (2/2)





- The helping nodes are distributed randomly
- The remaining battery lifetime beyond 30% is distributed randomly.
- The MCRBS is proved to help increase the possible routes about 200 additional routes at $N = 9$.

[5]. Siti Hartinah, Hario Prakoso, and Khoirul Anwar, Routing of Mobile Cognitive Radio Base Station for Disaster Recovery Networks, IEEE 2018 International Conference on Electrical Engineering and Informatics (ICELTICs), Banda Aceh, Indonesia, September 1920, 2018.

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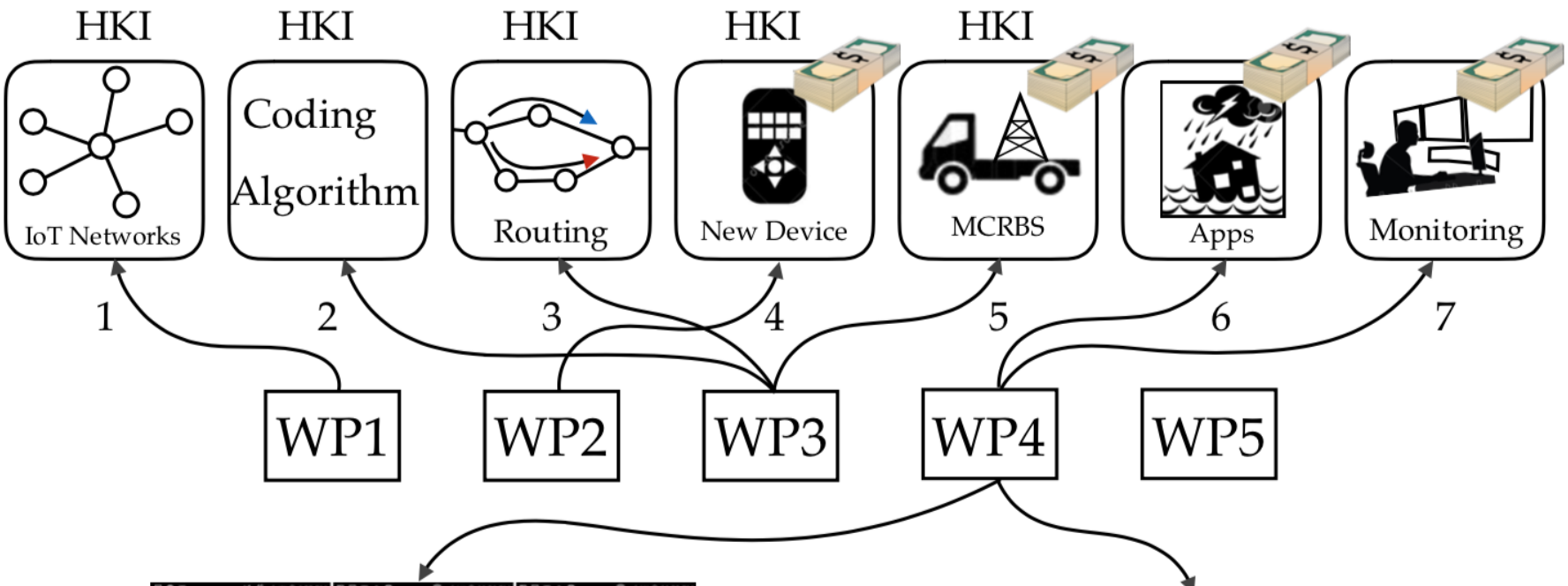
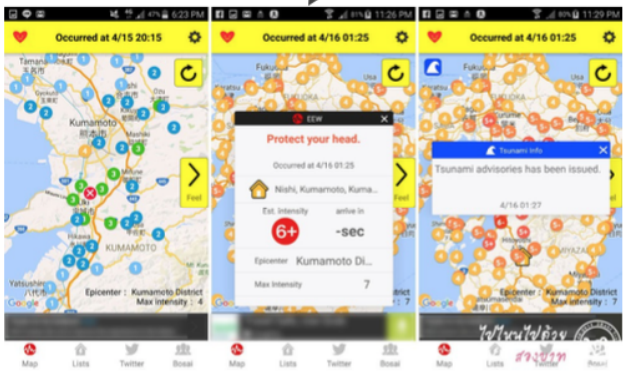
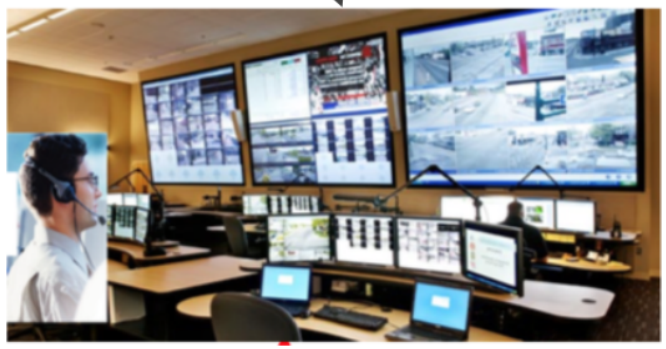
Expected Outcomes of PATRIOT-Net





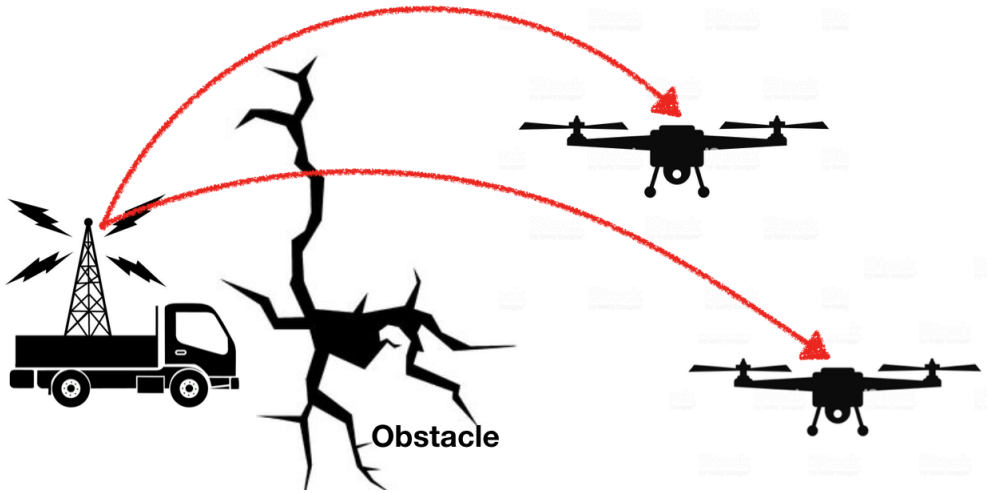
Apps



Monitoring Room

- 7 outcomes
- Outcomes 1–3: Patents; Outcomes 4–7: commercials

Next Progress Requiring Funding



- Testing Laboratory for the Sensor of Tsunami
  - It is difficult to find a lab for tsunami simulation.
- Extension to Drone for Stuck MCRBS
  - Some drones may be released to cover more wider areas
  - Communications quality ?, Power consumption for drones ?
- Implementation of deep learning for monitoring cameras $\rightarrow$ minimize communications of several sensors.

Conclusions

- We have proposed a 4-in-1 emergency network called PATRIOT-Net: Prevention and Recovery Networks for Natural Disasters based on IoT for (a) earthquake, (b) tsunami, (c) flooding, (d) landslide.
- We exploite 5G communications systems with possible deep learning applications for smart disaster monitoring and recovery networks.
- Preliminary results: (i) Multi-generations 2G-5G antenna, (ii) routing algorithm for several MCRBS and mobile phones.
- We expect to provide 7 outcomes.
- Next progress requiring funding: (a) Tsunami testing, (b) Drone-based extended MCRBS, (c) deep learning for camera that minimize sensor numbers.

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