Mobile WSN for Natural Disasters

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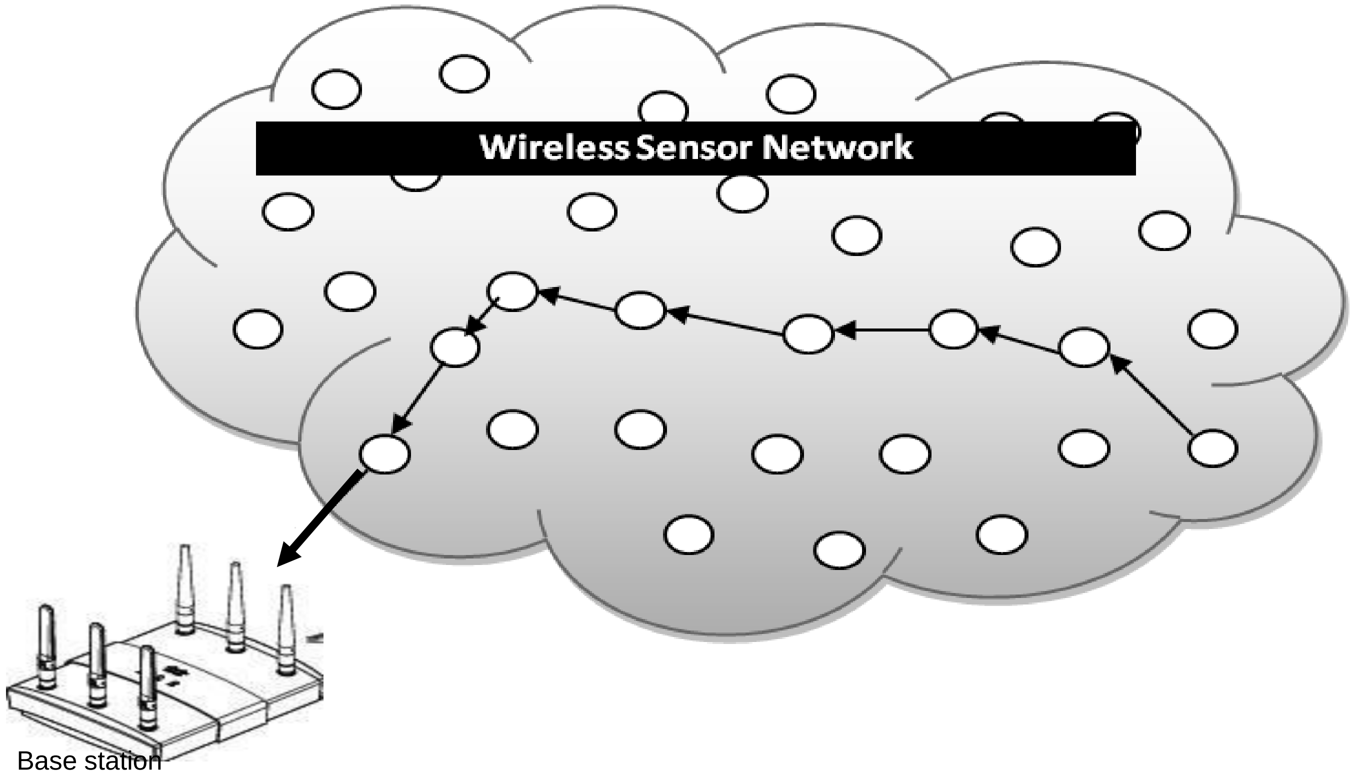
Jum’at, 28 Agustus 2020

Wireless Sensor Networks (WSNs)

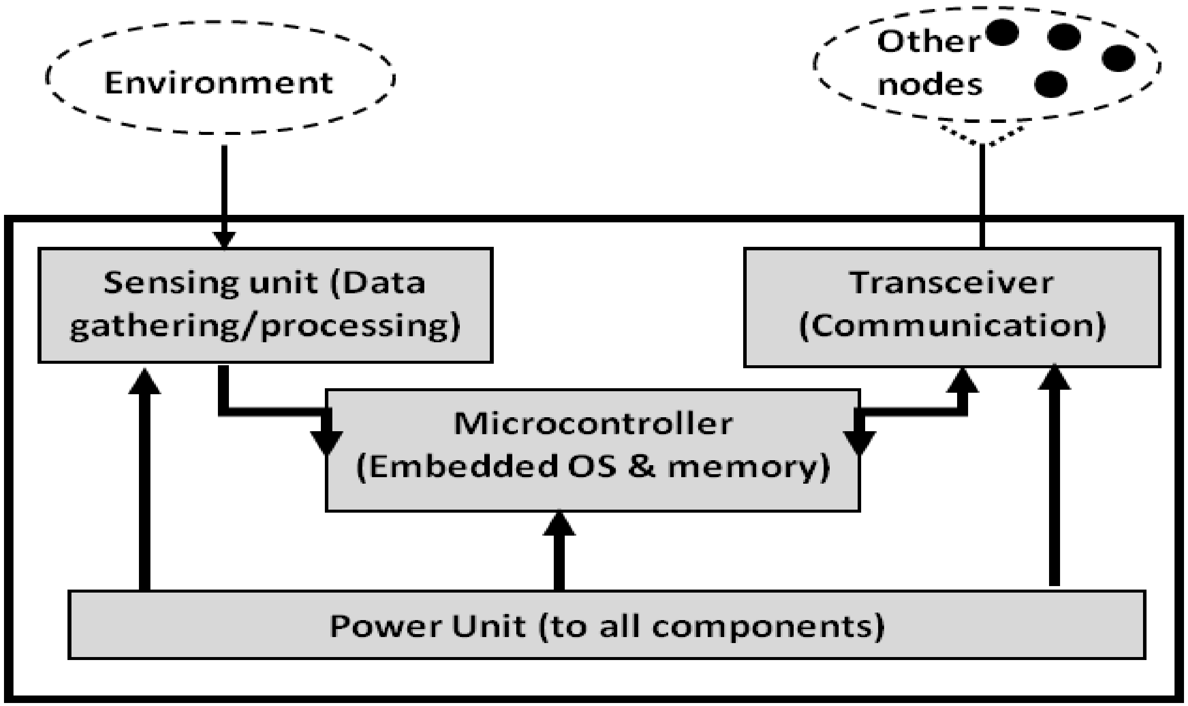
- A sensor network is a wireless network that consists of thousands of very small nodes called *sensors*.



Architecture of wireless sensor networks

Wireless Sensor Networks (cont.)

- WSN **Sensors** are equipped with sensing, limited computation, and wireless communication capabilities.



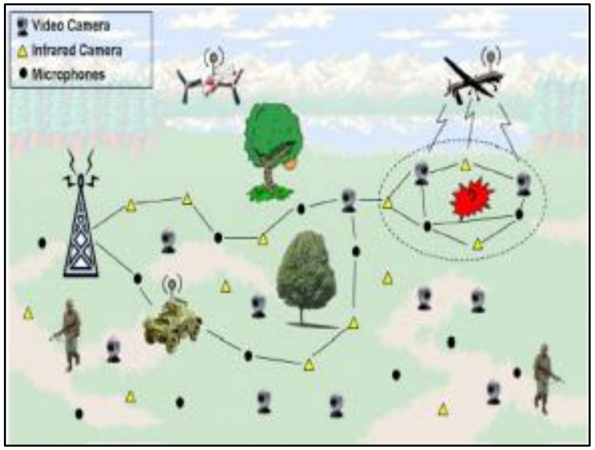
Typical hardware components of a sensor node in wireless sensor networks

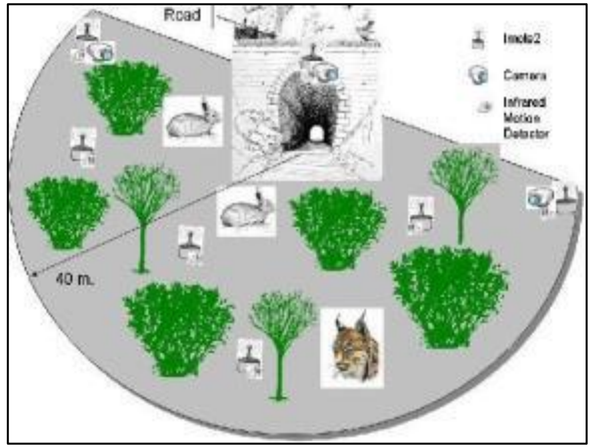
WSNs Applications

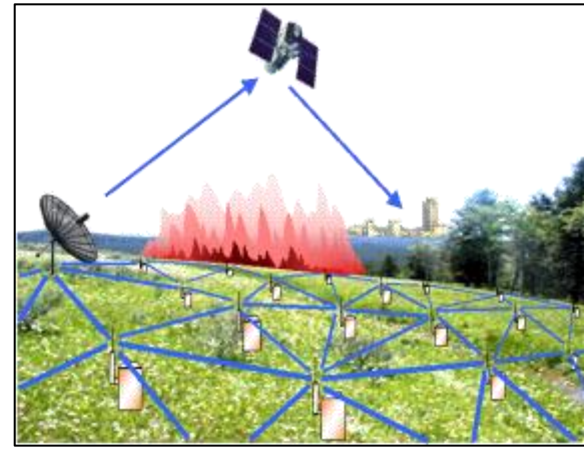
- WSNs have many advantages over traditional networking techniques.

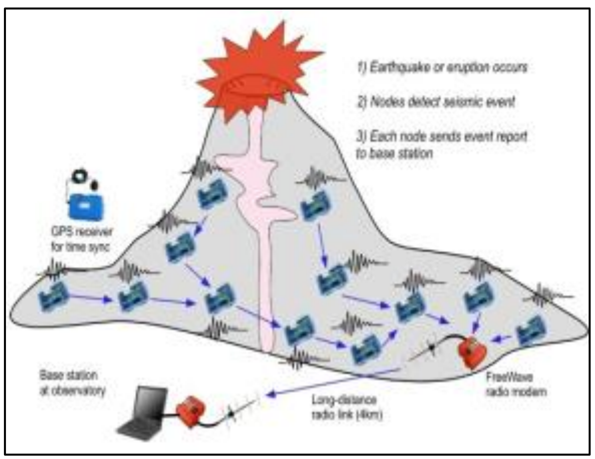
- They have an ever-increasing number of applications, such as infrastructure protection and security, surveillance, health-care, environment monitoring, food safety, intelligent transportation, and smart energy.

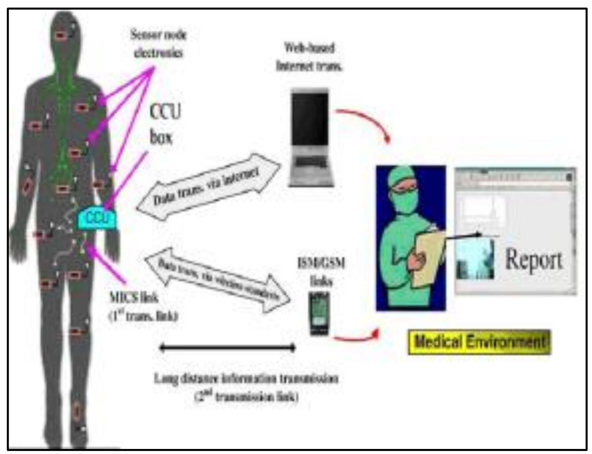
WSNs Applications

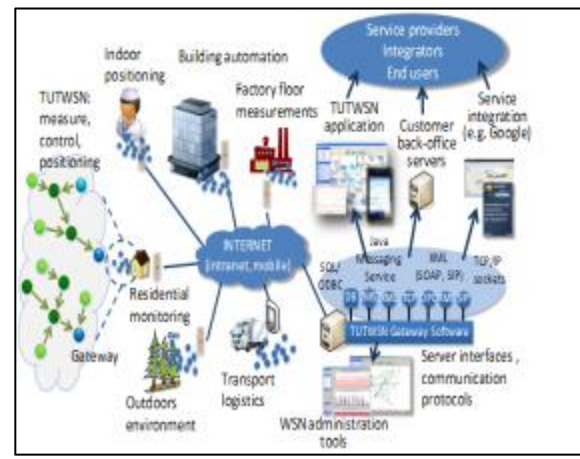












Applications of Wireless Sensor networks

The applications can be divided in three categories:

1. Monitoring of objects.
2. Monitoring of an area.
3. Monitoring of both area and objects.

Monitoring Area

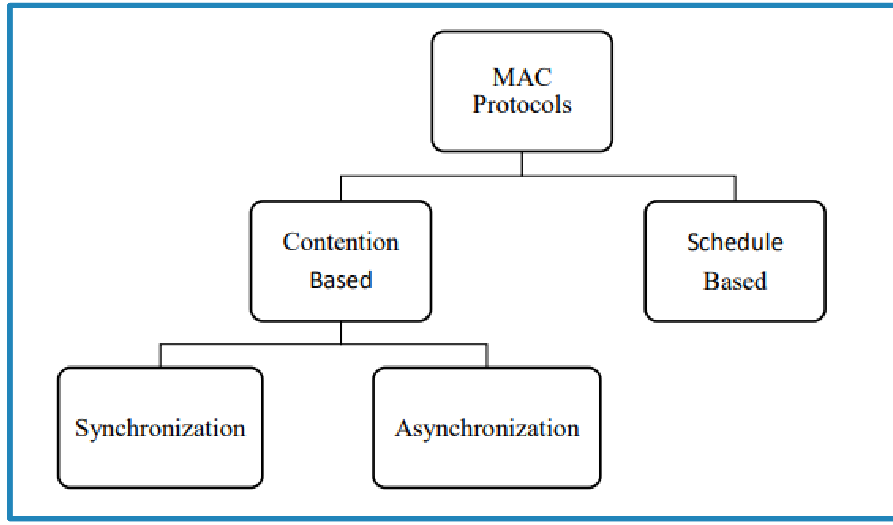
- Environmental and Habitat Monitoring
- Precision Agriculture
- Indoor Climate Control
- Military Surveillance
- Intelligent Alarms

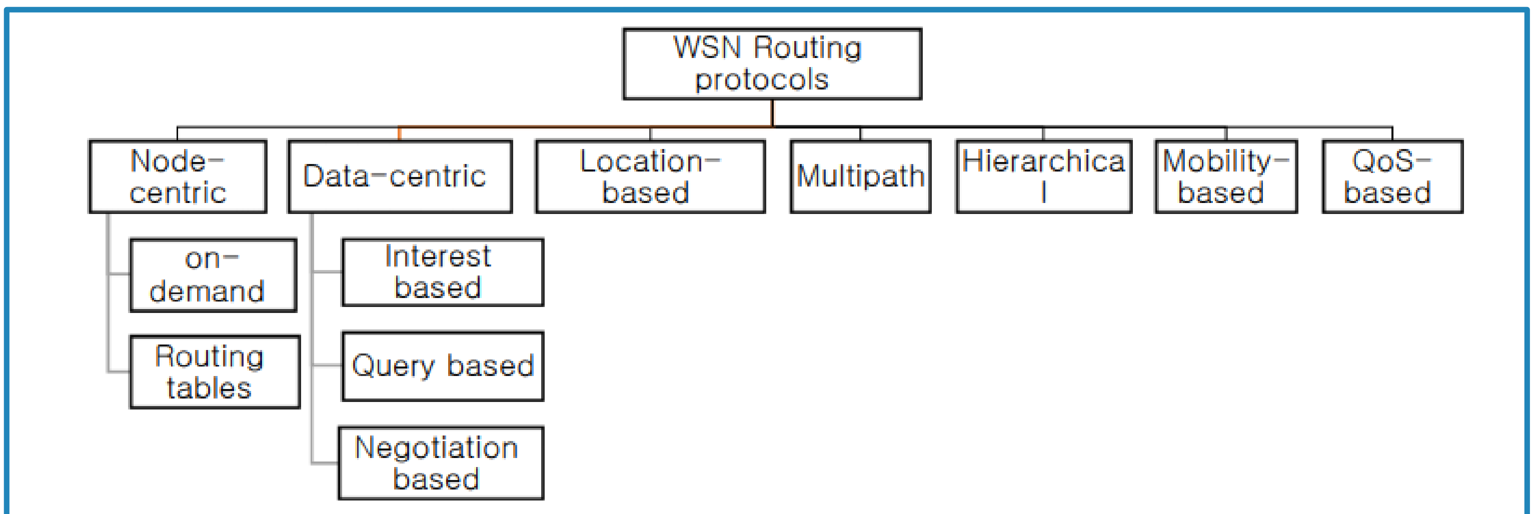
Challenges in WSN

Challenges	Required mechanisms
Resource constraints	Efficient use of resources
Dynamic and extreme environment conditions	Adaptive network operation
Data redundancy	Data fusion and localized processing
Unreliable wireless communication	Reliability
No global identification (ID) for sensor nodes	Data-centric communication paradigm
Prone to node failures	Fault tolerance
Large scale deployment	Low-cost small-sized sensors with self-configuration and self-organization

Designing Protocol of WSN

APPLICATION LAYER	Data aggregation, interactions with the end user
TRANSPORT LAYER	Reliable transport of data
NETWORK LAYER	Routing, networking, topology management
DATA LINK LAYER	Medium access and error control, data frame detection, multiplexing
PHYSICAL LAYER	Modulation, frequency and channel selection, signal processing





A Survey on Protocols, Platforms and Simulation Tools for Wireless Sensor Networks, 2014

Simulation Tools for WSN

Tools / Features	Interface	Accessibility & User Support	Availability of WSNs Modules	Extensibility	Scalability
NS -2	C++/OTcl with limited visual support	Open source with Good user support	Energy Model, battery model, Mobility	Excellent	Limited
OMNeT++	C++/NED with good GUI and debugging support	Free for academic use, licence for commercial use with Good user support	Energy Model, battery model, accurate wireless channel and radio modelling	Excellent	Large-scale
GloMoSim	Parsec (C-Based) with limited visual support	Open source with Poor user support	Sensor network specific MAC and network protocols, mobility model	Good	Large-scale
OPNET	C or C++/Java with Excellent GUI and debugging support	Free for academic use, licence for commercial use with Excellent user support	Energy model, battery model, Routing protocols (directed diffusion), Mobility, node failure model	Excellent	Moderate
SENSE	C++ with good GUI support	Open source with Poor user support	Energy models, battery models, Mobility, modelling of physical environment	Excellent	Large-scale
TOSSIM	C++/Python with good GUI support	Open source (BSD) with Excellent user support	Energy models with power TOSSIM ads-on, Bit-level radio model	Good	Large-scale
GTSNetS	C++ with good user interface & visual support	Open source with good user support	Energy model, battery model, accuracy model, model applications, Mobility	Excellent	Very large-scale

M. Zahid, B. Askwith, F. Bouhafs, M. Asim, Limitations of Simulation Tools for Large-Scale Wireless Sensor Networks, 25th IEEE International Conference on Advanced Information Networking and Applications Workshops, WAINA 2011, Biopolis, Singapore, 2011

What are motes?

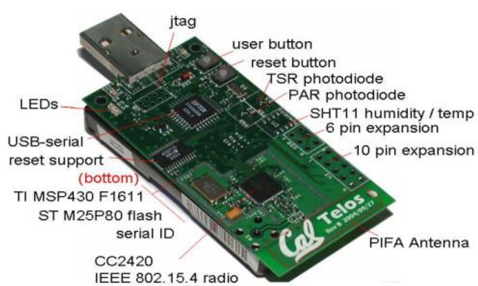
Motes mainly consist of three parts:-

- Mote basically consists of a low cost and power computer.
- The computer monitors one or more sensors. Sensors may be for temperature, light, sound, position, acceleration, vibration, stress, weight, pressure, humidity, etc.
- The computer connects to the outside world with a radio link.

MICA 2

http://www.xbow.com

TELOSB



http://www.eecs.berkeley.edu

ARDUINO

https://www.arduino.cc/

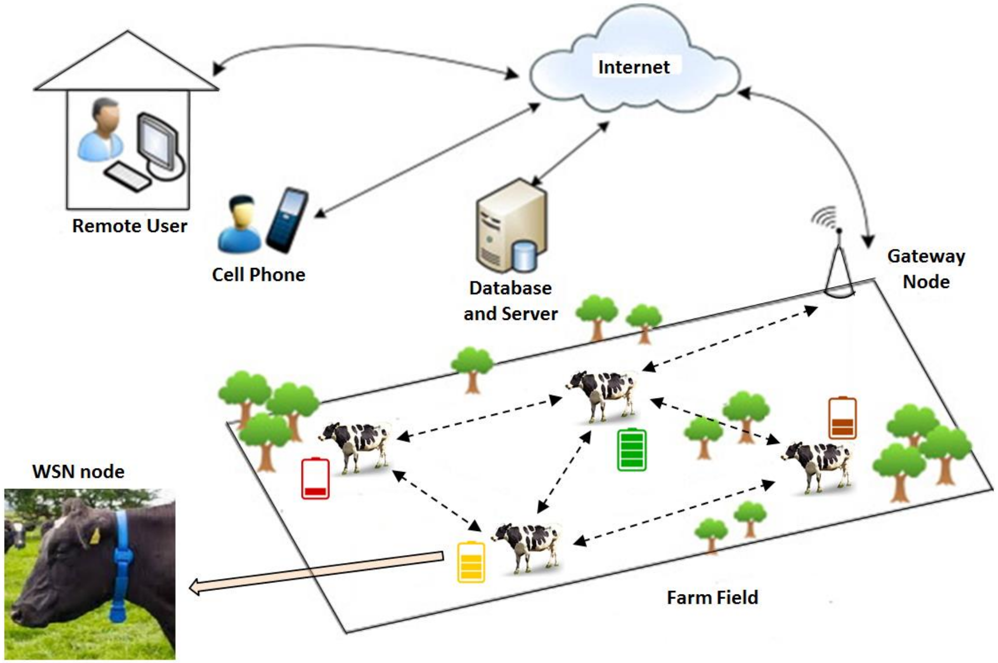
RASPBERRY PI

https://www.raspberrypi.org/products/

WASPMOTE

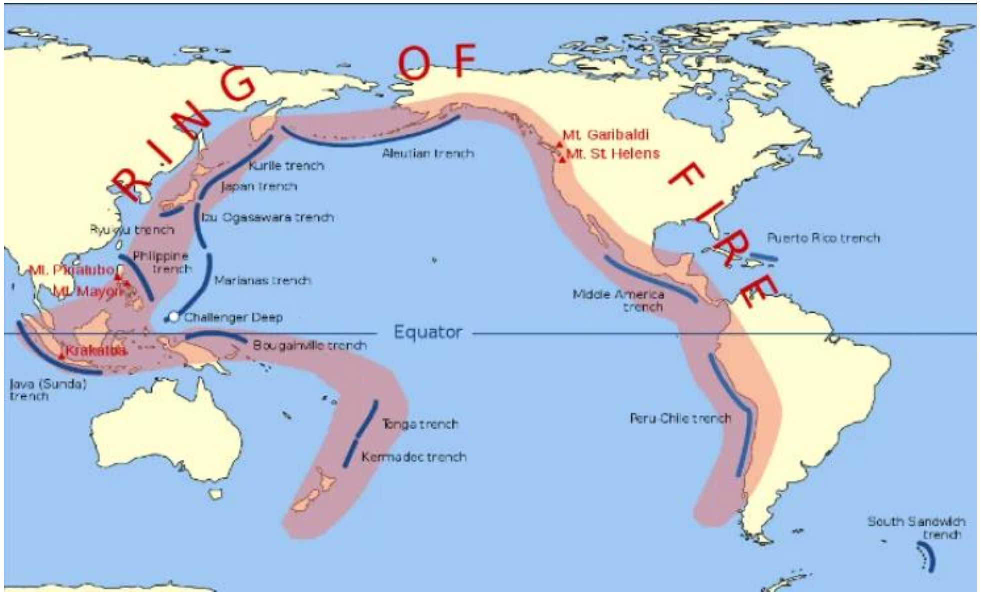
http://www.libelium.com/products

Mobile Wireless Sensor Networks (WSN)



- Applications with considering mobility:
  - Animal Monitoring
  - Search-and-Rescue Operations
  - Healthcare Monitoring
  - Evacuation Systems

Natural Disasters



Aceh, Indonesia, 2004

Miyako (Iwate), Japan, 2011

Natural disasters:
Flood
Earthquakes
Tsunami

- **Many people died**
- **Health condition of the victims become drop**

It needs evacuation system and health monitoring

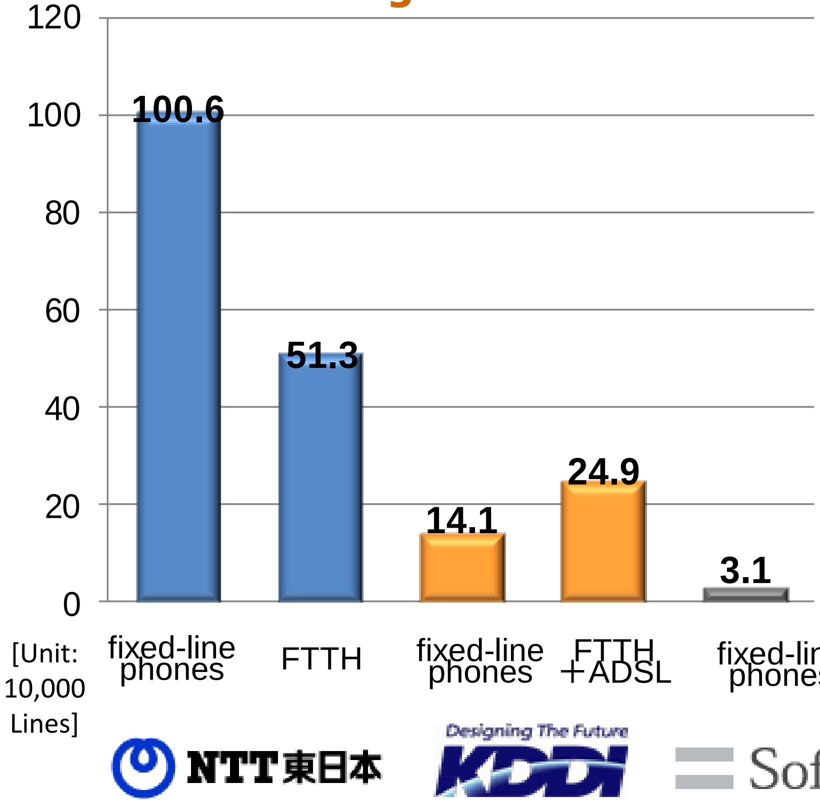
Natural Disasters in Indonesia (BNPB)

Motivation: Damage to Fixed Lines, Mobile Base Stations

Fixed-line Communications

- In total, around 1.9 million communication lines were damaged.

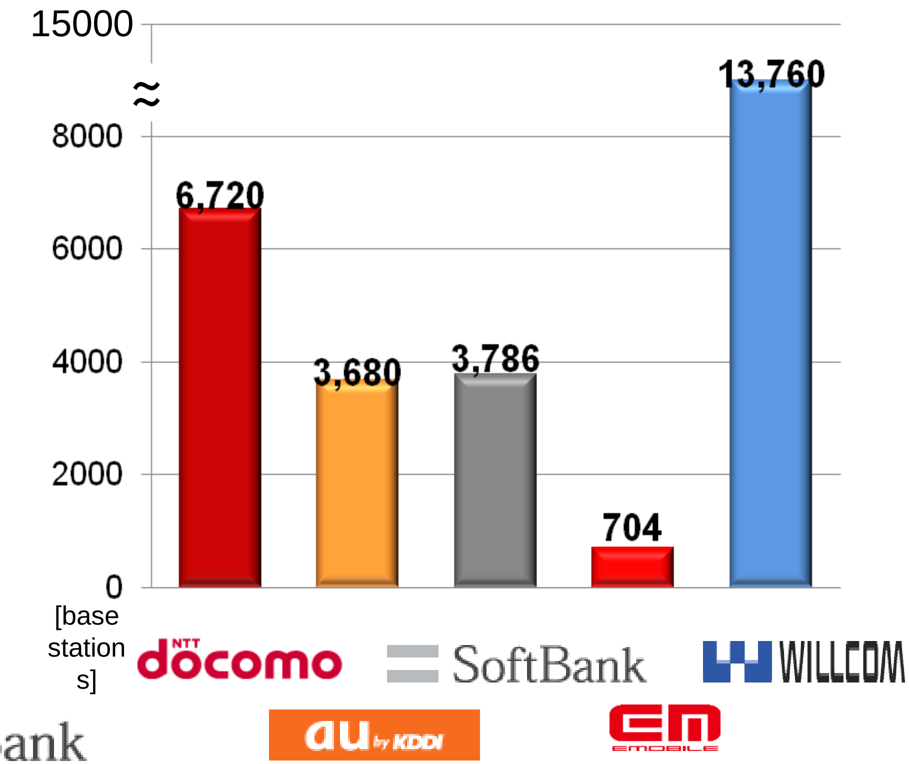
Max. no. of damaged lines



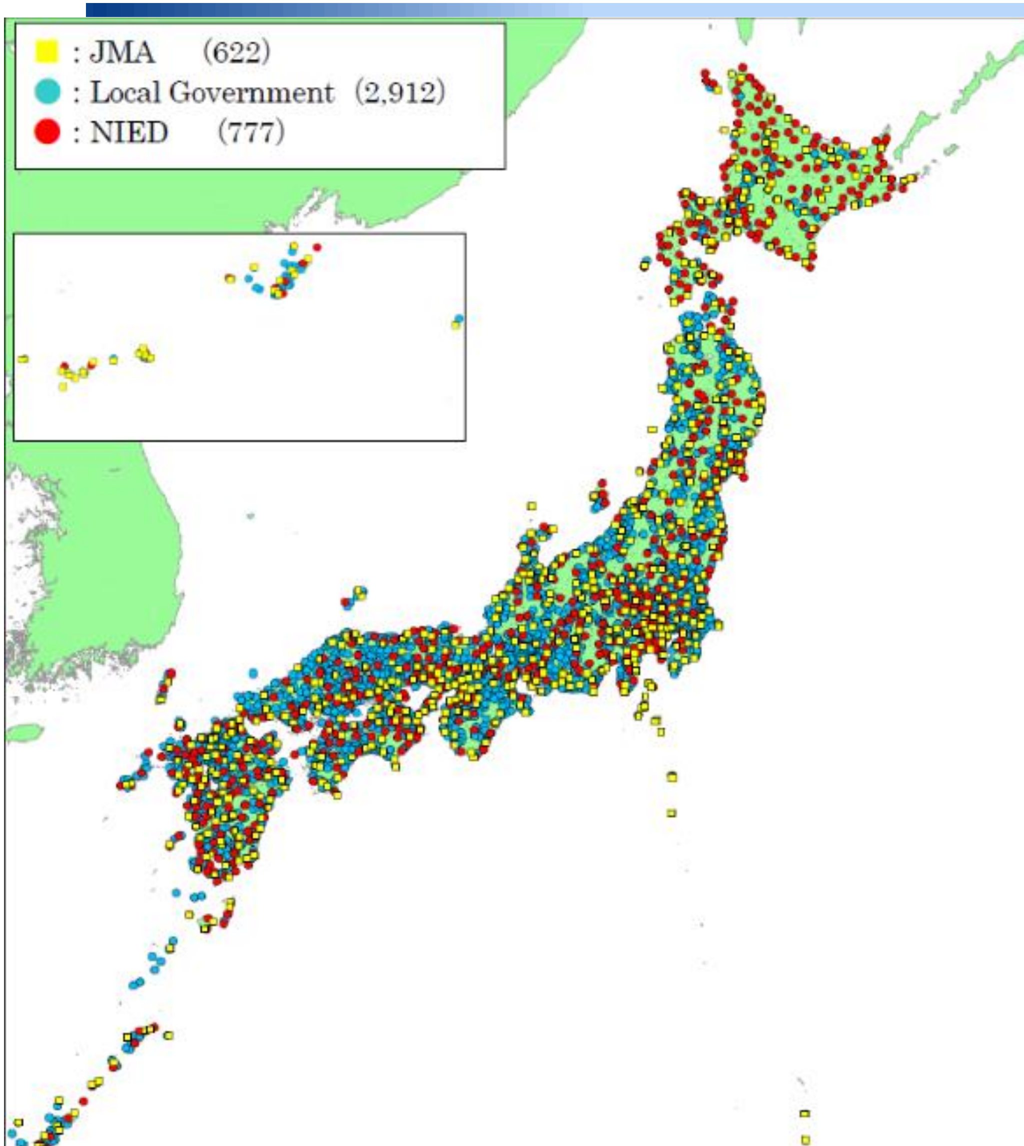
Mobile Communications

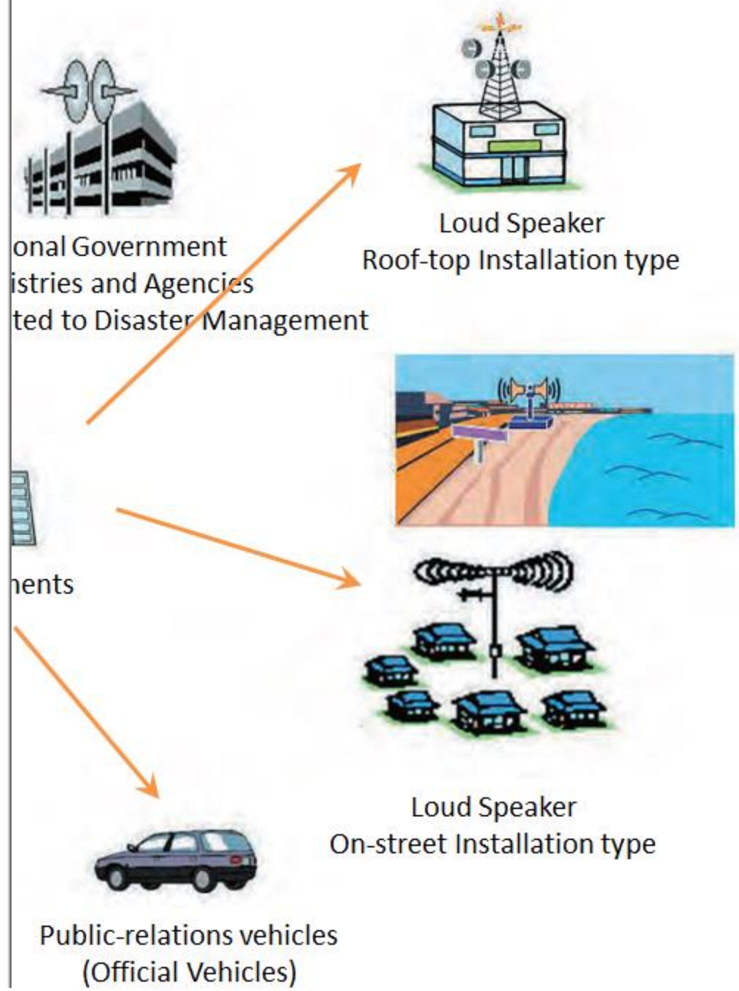
- In total, about 29,000 base stations were damaged.

Max. no. of damaged base stations



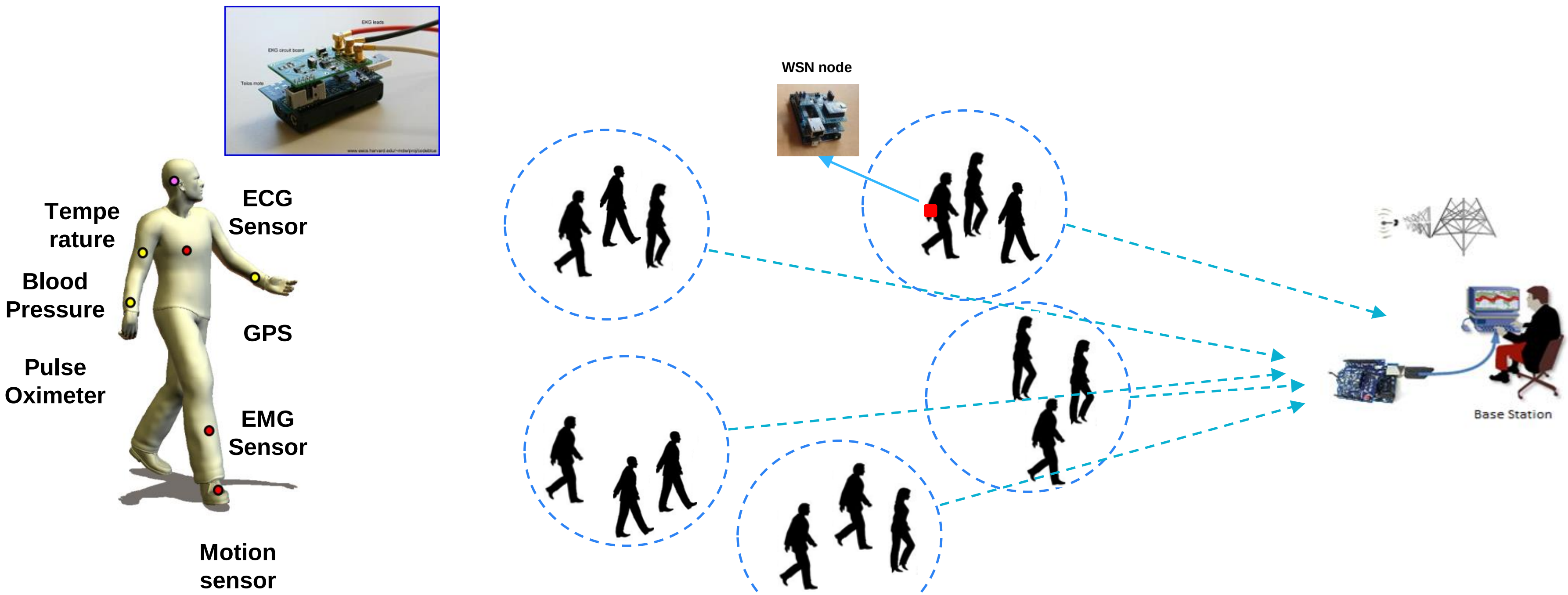
Disaster Management





Source: Cabinet Office, *Disaster Management in Japan*

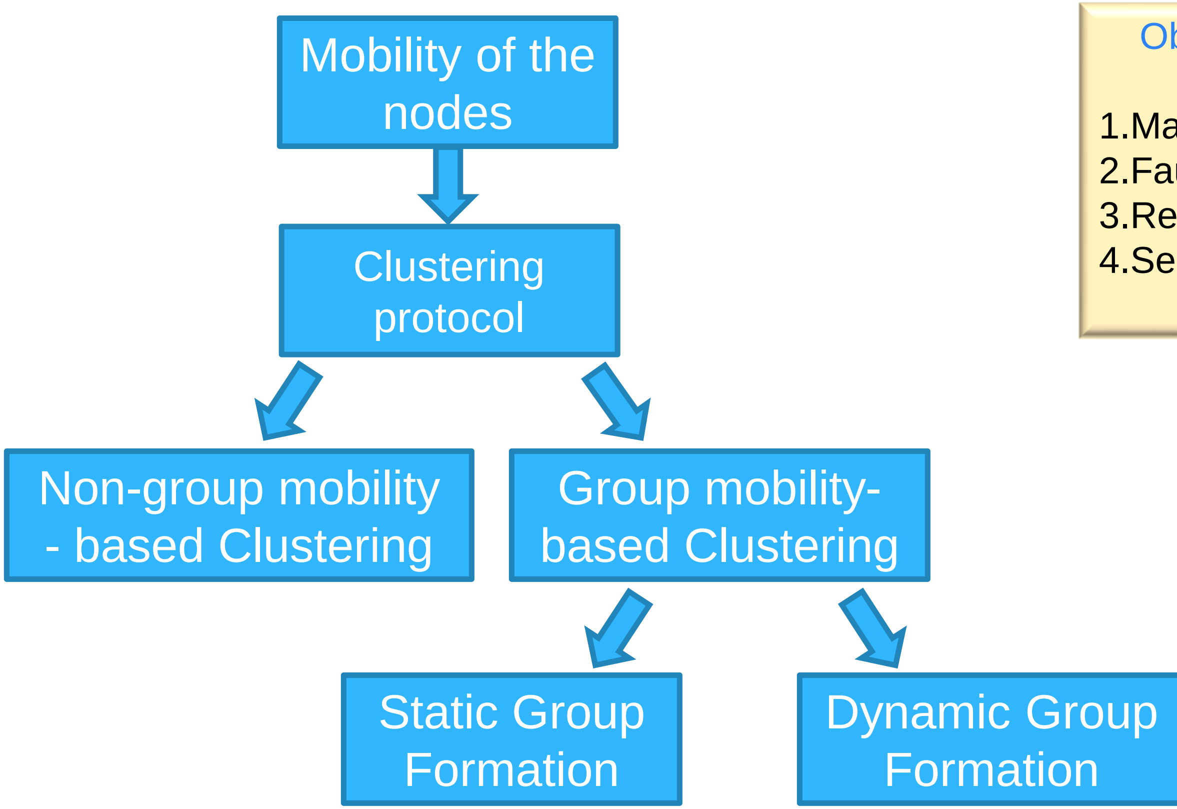
Evacuation System



- In natural disaster, people will move in a group to go to a safe area.
- It allows a dynamic group change when a person moves to other groups.

System Framework

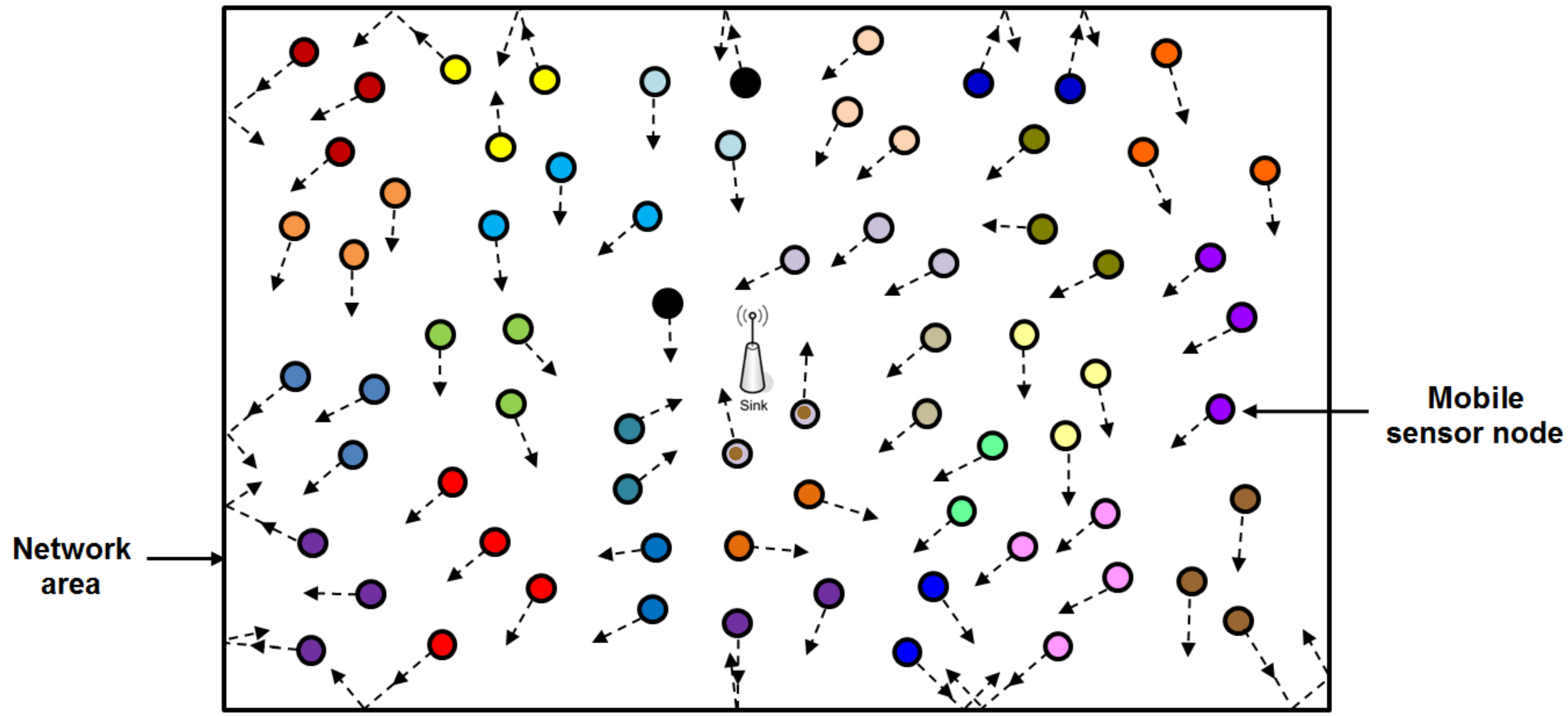
Group Mobility System Framework



Objectives of clustering protocol:

1. Maximal network lifetime
2. Fault tolerance
3. Reduce collision (TDMA)
4. Self configuring

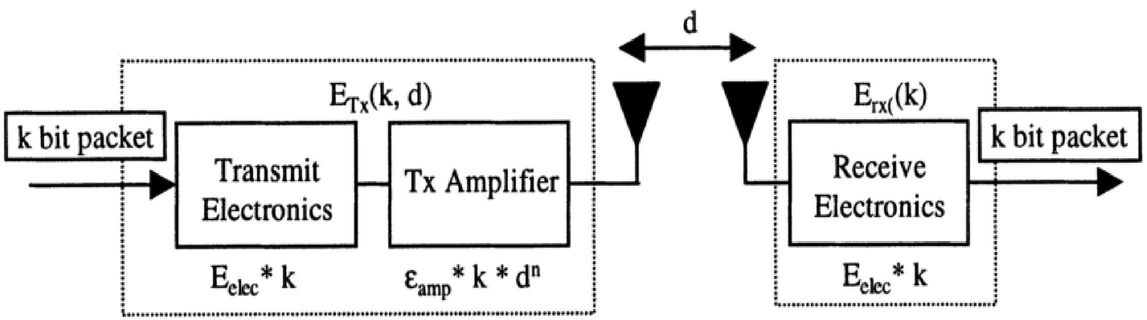
System Models: Network Model



- Sensor nodes move in group into some direction randomly inside network area.
- If the movement of nodes reach the edge of network area, the nodes will turn back their direction into inside the area again.

System Models: Energy Model

Radio energy dissipation model



Transmitter energy

$$E_{TX}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$

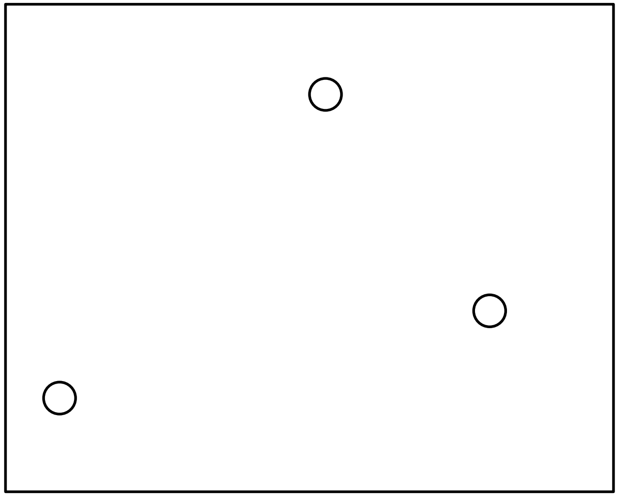
$$E_{TX}(k,d) = \begin{cases} k.E_{elec} + k.\varepsilon_{fs}.d^2, & d < d_{crossover}\ (Free\ Space) \\ k.E_{elec} + k.\varepsilon_{mp}.d^4, & d \geq d_{crossover}\ (Multipath) \end{cases}$$

Receiver energy

$$E_{RX}(k) = E_{RX-elec}(k) = k\ .E_{elec}$$

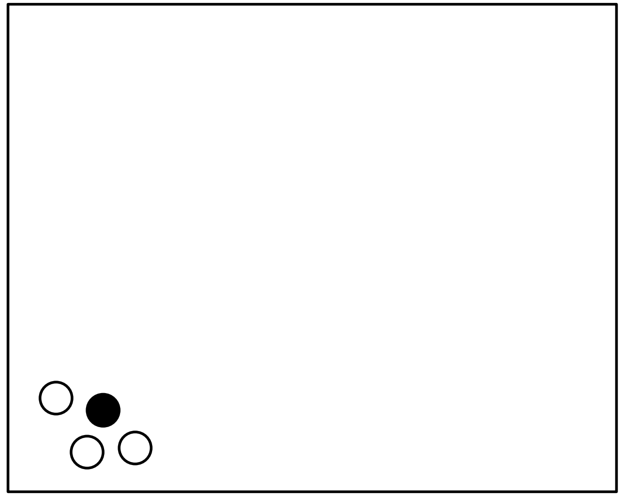
System Models: Mobility Model

Non-group mobility



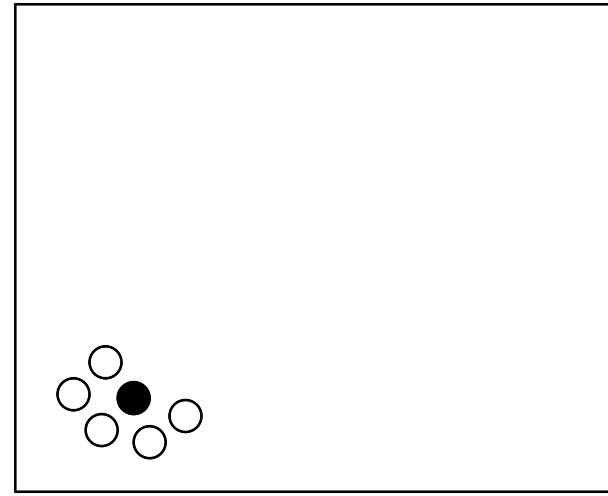
Random Way Point (RWP)

Group mobility



Reference Point Group Mobility (RPGM)

Group mobility

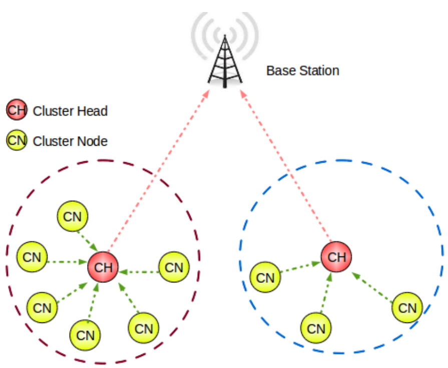


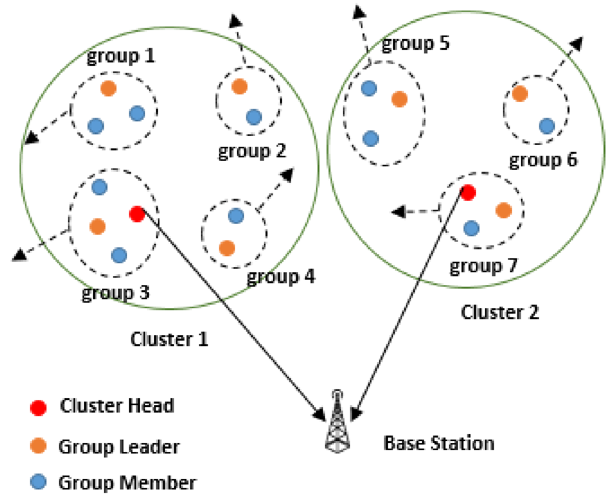
Nomadic Community Mobility (NCM)

- RWP is a random model for the movement of mobile users along a straight line segment from one point to the other.
- In RPGM, each node belongs to a group follows a logical center that determines the flow of the entire group.
- In NCM, some mobile nodes would roam separately from their group around a particular location for a while.

EMGC protocol

Network structure



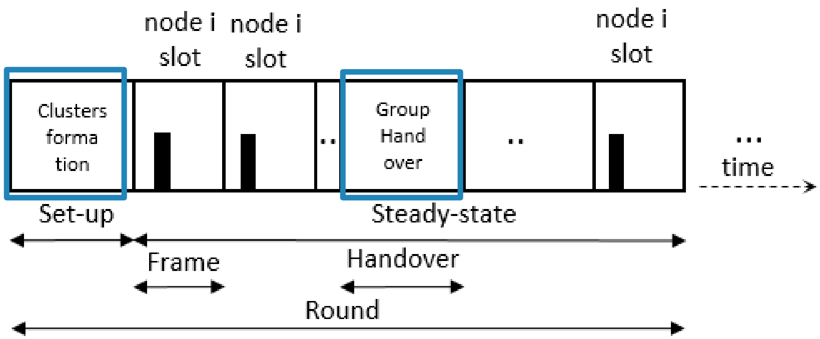


Issues:
Group Movements
Group Handover

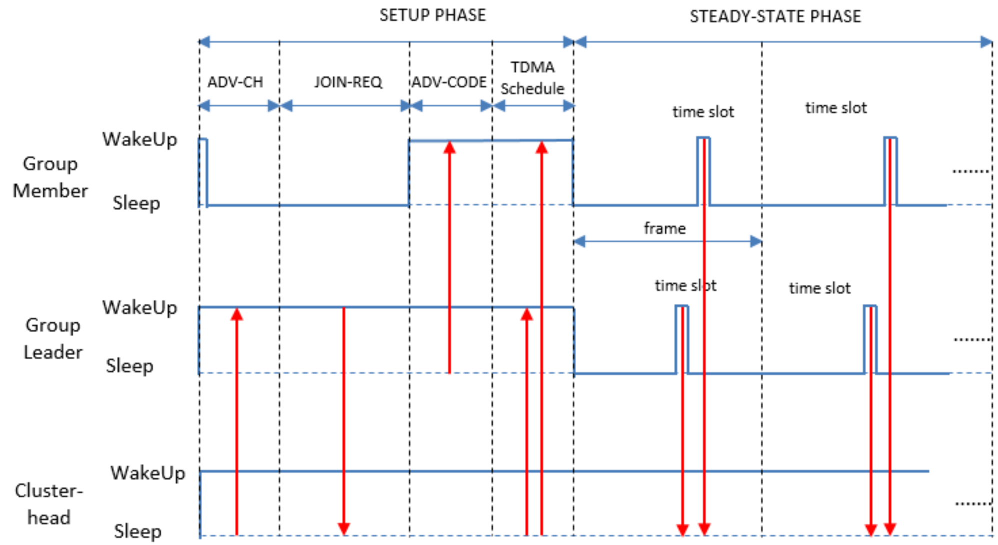
- It consists of three categories of mobile nodes:
  - Cluster Head (CH): major role in cluster formation and to send an aggregated data to BS
  - Group Leader (GL): to make a communication with CH in the set-up and steady-state phase
  - Group Member (GM): as a normal node
- Group formations of all sensor nodes have been determined initially and there is no change in the roles of the group leader and group members.

EMGC protocol: Process

Slot structure



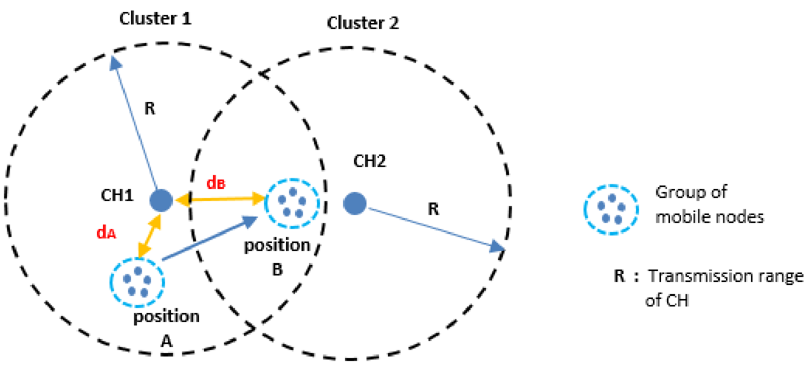
Timing scheme



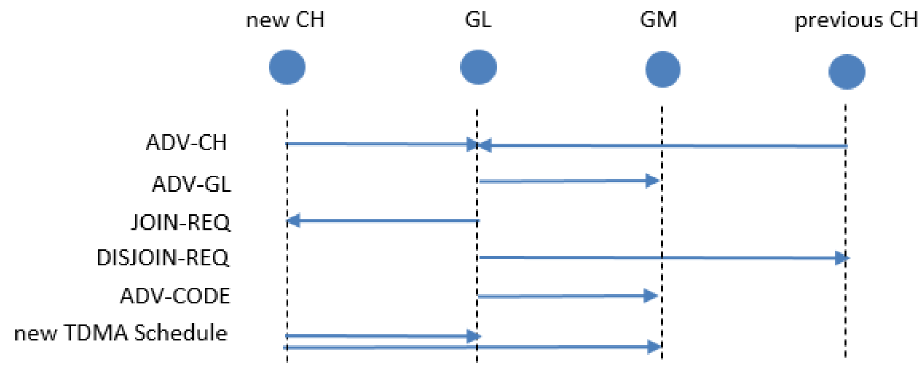
- There are two phases:
  - Set-up phase: cluster formation with three category nodes
  - Steady-state phase: data delivery to a BS with group handover

EMGC Protocol: Group Handover

Group handover process



Group handover procedure



- A two-step decision to decide group handover:
  1. Calculate a willingness ($F_j(r)$) to join the new cluster

$$F_j(r) = d_j(t_{hr}) - d_j(t_{sr})$$

Distance GLj to CH1 at pos. A   **Distance GLj to CH1 at pos. B**

  2. If *F* is positive (the group moves away), it will choose the best cluster.

$$H_j(r) = \arg\min_k d_j(t_{hr})$$

Distance GL_j and CH_k at round *r*

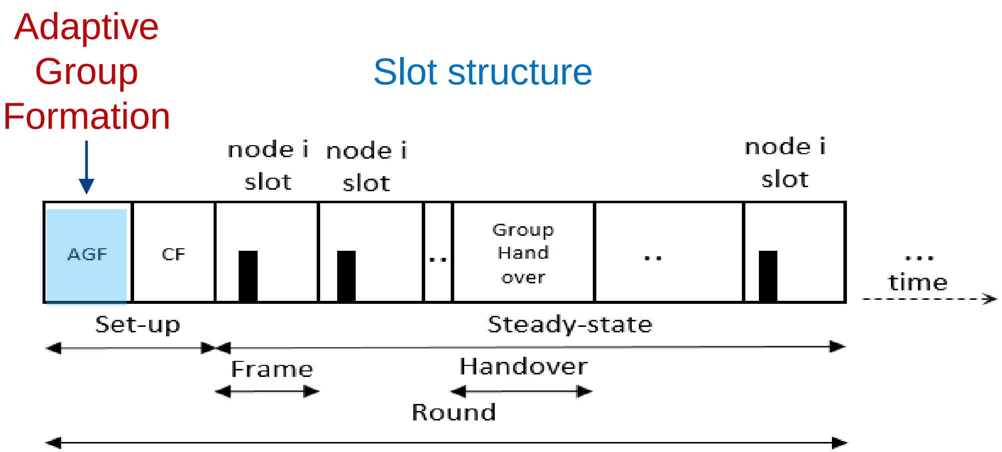
Advanced EMGC

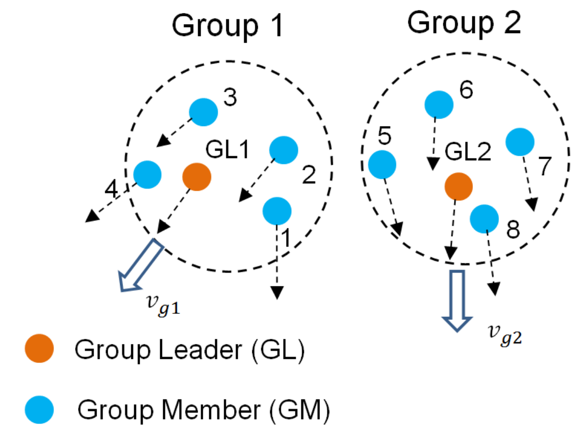
- To address a dynamic group change in clustering scheme.
- To address high percentage number of groups problem.
- To reduce the number of control packets and collisions.
- To prolong lifetime of the network.
- To deliver more data to a BS.

To address the above problems, we propose:

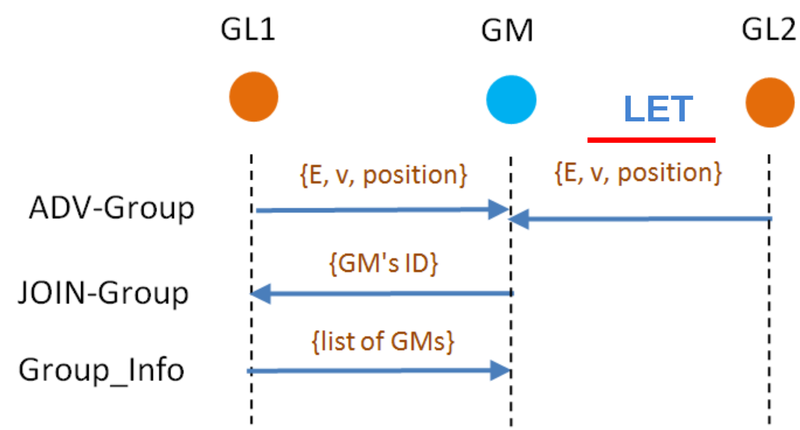
Adaptive Group Formation with EMGC (AgEMGC) for mobile group WSNs

AgEMGC Protocol: Basic Function



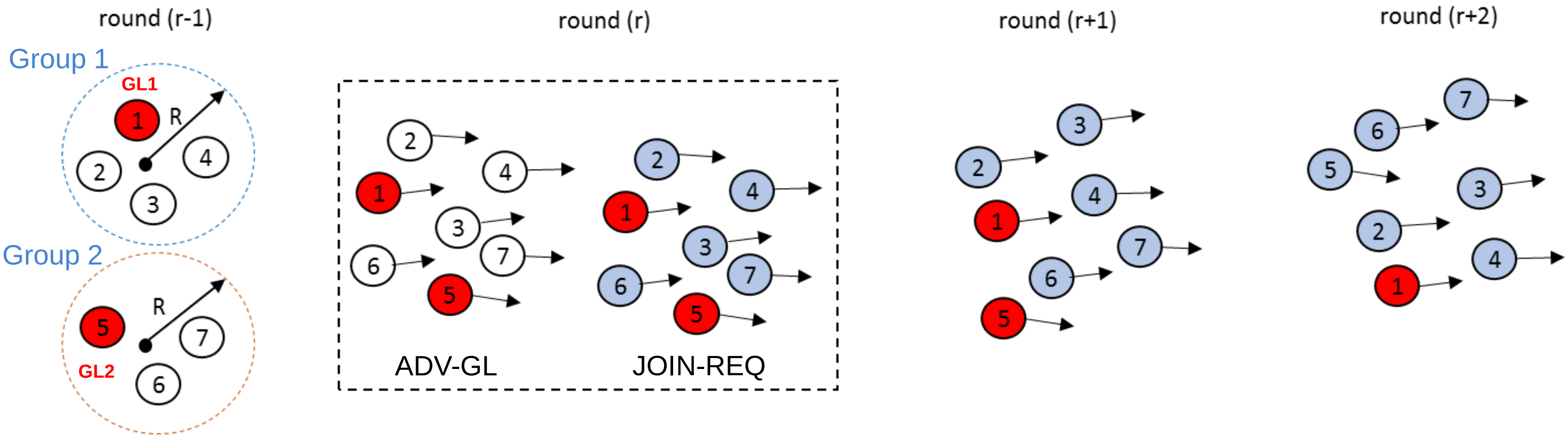


Basic function



- There are 2 basic functions:
  - A dynamic group change
  - Group merging
- There are two additional functions:
  - GL rotation: to reduce the energy consumption
  - A stay Connection procedure: to reduce the control packet

AgEMGC: Group Merging



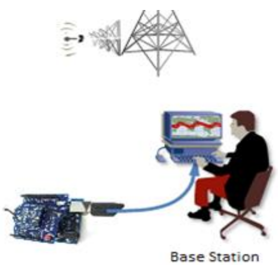
- At round(r-1), there are two mobile groups.
- At round(r), the groups are close each other and all neighbors join the GL1 as GMs of Group 1 when the GLs broadcast a message.
- At round(r+1), GL2 broadcasts a message again to confirm whether any GMs want to join. If there is no GM, GL2 will change its function from a GL node to a GM node.
- At round (r+2), GL2 joins the other group as GM.

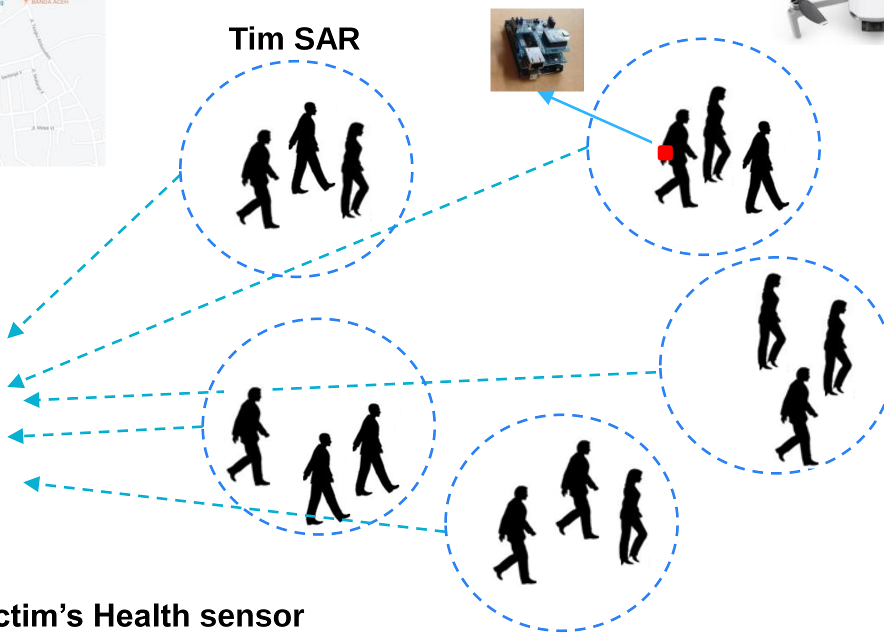
Projects in WSN

Sistem Informasi m-SAR
(mobile WSN – SAR)

Project 1

Posisi tim SAR

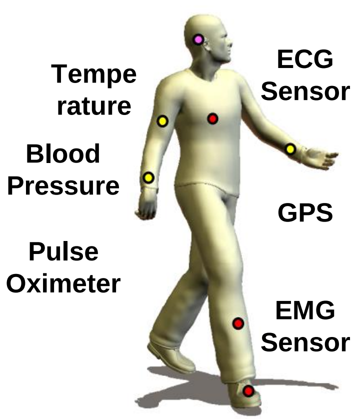




Daerah bencana

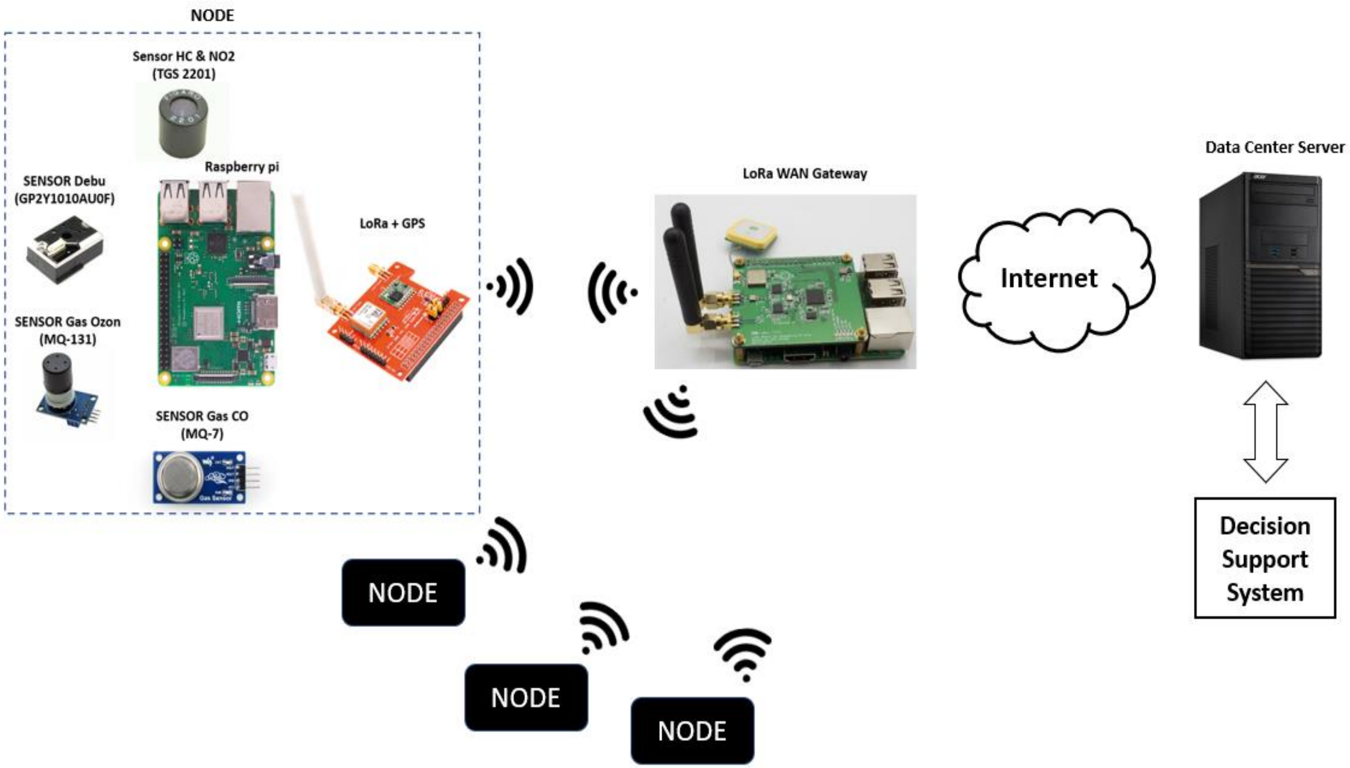
Human presence sensor:
- Thermal sensor
- Infrared (IR) sensor
- Piezoelectric sensor
- Ultrasonic sensor
- Motion detection sensor

Victim's Health sensor



Task:
1. Platform m-SAR
2. Protokol komunikasi berbasis mobile group (2D dan 3D)

Project 2



- Environment monitoring at Surabaya Industrial Estate Rungkut (SIER), Surabaya

THANK YOU

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WA: 081292109194