AUM AMRITESWARYAI NAMAH

Wireless Sensor Network for Detecting Disasters

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Disasters

- Between 2000 and 2012, natural disasters caused
  - $1.7 trillion in damage
  - affected 2.9 billion people
  - 1.1 million people were killed
- Worldwide in 2011, there were
  - 154 floods,
  - 16 droughts, and
  - 15 cases of extreme temperature
- 2012 → natural disaster damage exceeding $100 billion.

Disasters

- Floods
  - the most widespread natural disaster
- Earthquakes:
  - cause associated destruction of man-made structures
  - instigate other natural disasters such as tsunamis, avalanches, and landslides
- Hurricanes
  - coupled with storm surges and sever flooding
- Landslides
  - often accompany earthquakes, floods, storm surges, hurricanes, wildfires, or volcanic activity
  - often damaging and deadly than the triggering event

Monitoring Techniques

- Large Scale Monitoring (Macro)
  - Satellite Systems
  - Remote Sensing
  - Mobile Vehicle Based Sensing
- Site Specific Monitoring (Micro)
  - Wireless Sensor Network
  - Mobile Computing
- Participatory Sensing/Monitoring
  - Mobile Phone
  - Participants participation

- Area of Monitoring
- Frequency of Monitoring
- Knowledge of Location
- Uncertanity

Disasters Vs. Parameters

Disasters

- Landslide
- Flood
- Drought
- Hurricane
- Storms
- Avalanche
- Forest Fire
- Earthquake

Parameters

- Rainfall
- Moisture
- Water Level
- Wind
- Movement
- Temperature
- Humidity
- Vibration

Requirements for Monitoring

Sub Systems

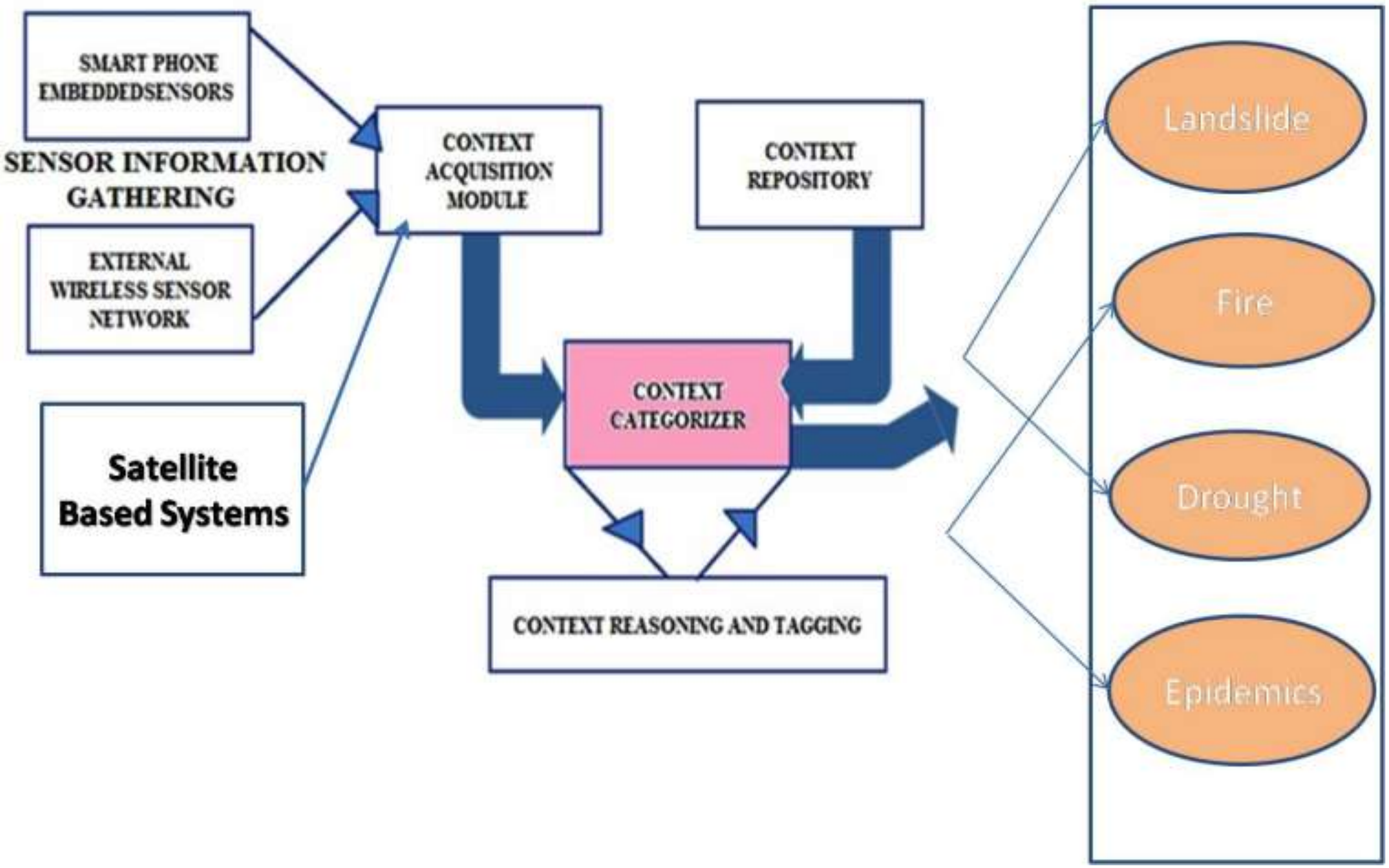
- Sensors
- Data Collection Techniques
- Data Aggregation Techniques
- Real-time Communication Technology
- Complex Data Analysis
- Multiple methods for detection
- Alert Dissemination

Required Functionalities

- Long Term Monitoring
- Network Lifetime Extension
- Fault Tolerant Communication Technology
- Heterogeneous Data Aggregation, Analysis
- Multi-path for Alert Dissemination

Major disasters instigate other multiple types of disasters

Ubiquitious Mult-Context Model

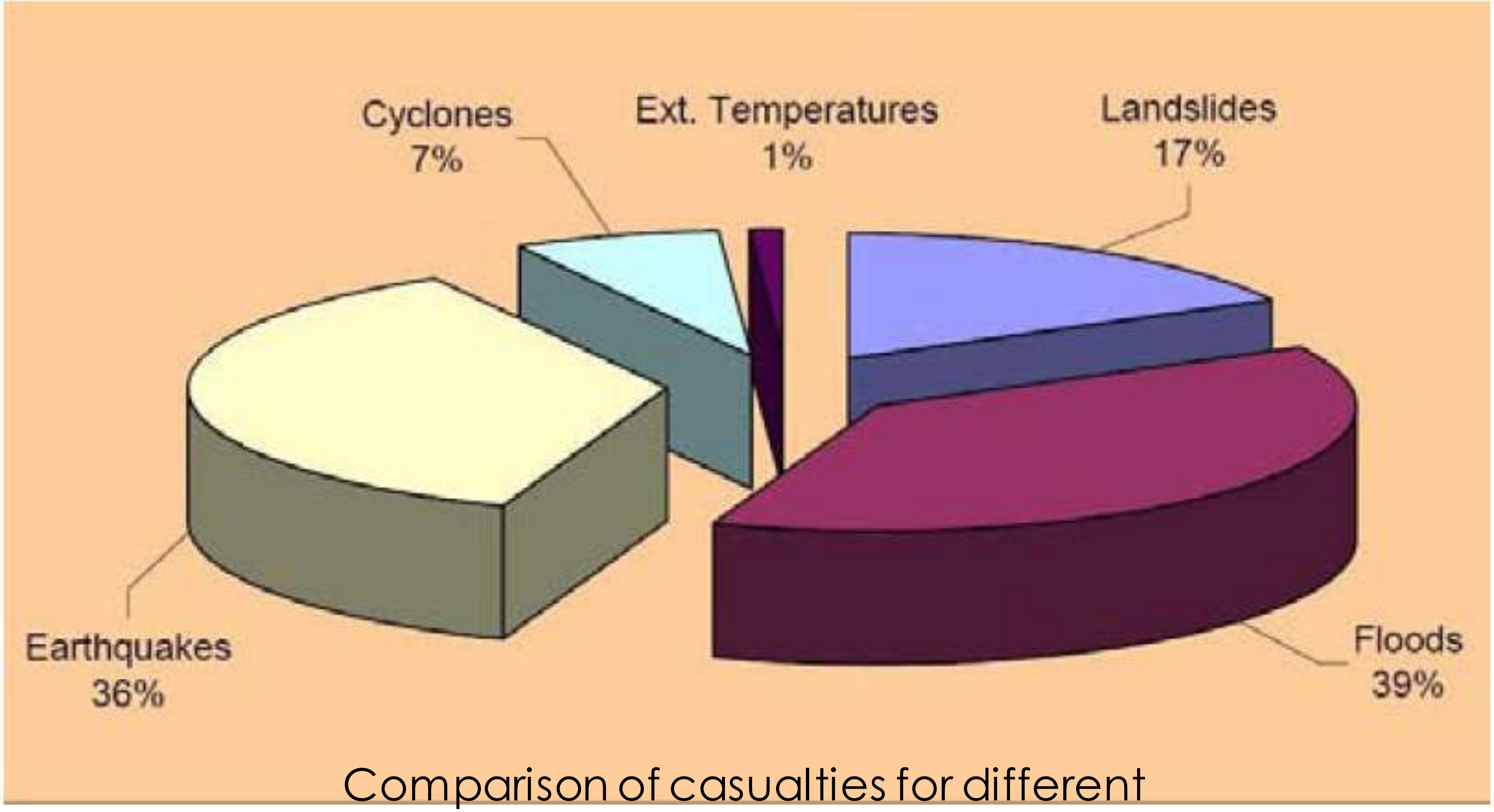


Wireless Sensor Network for Monitoring and Detection of Landslides

Amrita University

Introduction

- Environmental Disasters: Landslides are the third most deadly natural disaster on earth



Comparison of casualties for different natural hazards (Source: CRED)

Introduction

- Environmental disasters are largely unpredictable and occur within very short spans of time.
- Wireless sensors are one of the cutting edge technologies that can quickly respond to
  - Rapid changes of data,
  - Process data, and
  - Transmit the sensed data

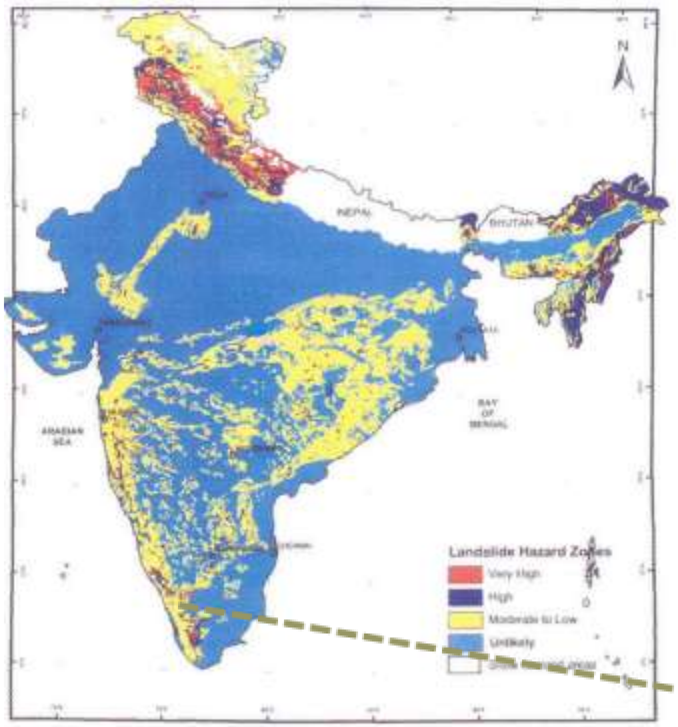
- Limitations include
  - relatively low amounts of battery power and
  - low memory availability compared to many existing technologies
- Main advantage: Deploying sensors in hostile environments with a bare minimum of maintenance.

Major Outcomes

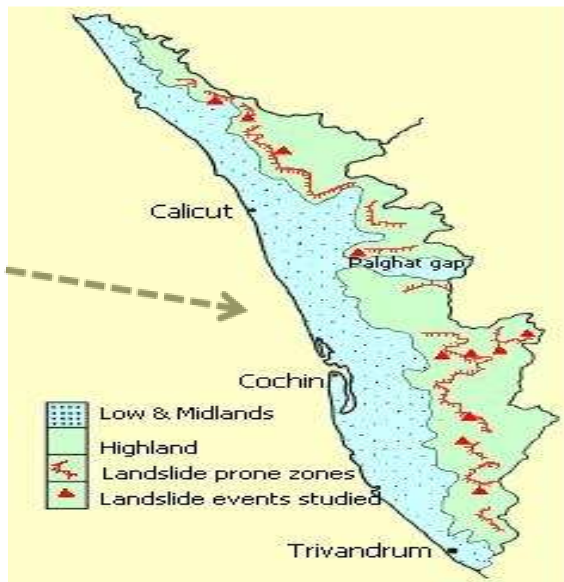
- **“World’s first ever comprehensive wireless sensor network for landslide detection”-AMRITA wireless sensor network for landslide detection**
- **“India’s first ever landslide laboratory set up for landslide detection”-AMRITA landslide laboratory set up for landslide detection**

Landslides

- **The rapid down-slope movement of soil, rock and organic materials under the influence of gravity.**
  - **Short-lived and suddenly occurring phenomena**
  - **Causes extraordinary landscape changes and**
  - **destruction of life and property**
- **In India,**
  - **Landslides mainly happen due to the heavy rainfall.**
  - **Annual loss due to landslides equivalent to $400 million**
- **This study concentrates on *rainfall induced landslides***



Landslide Risk Zones in Kerala



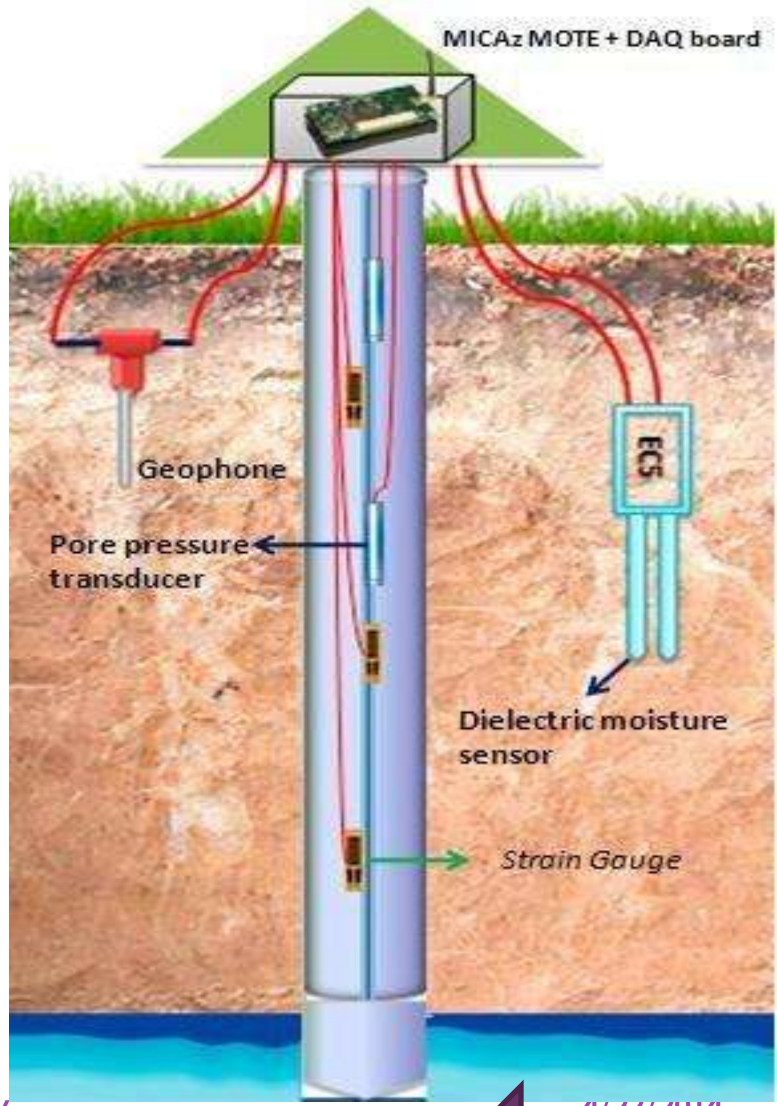
Landslide Prone Area - Munnar

Anthoniar Colony is located 700 meters Northwest of Munnar town.
Two levels of slide were observed at Anthoniar Colony.

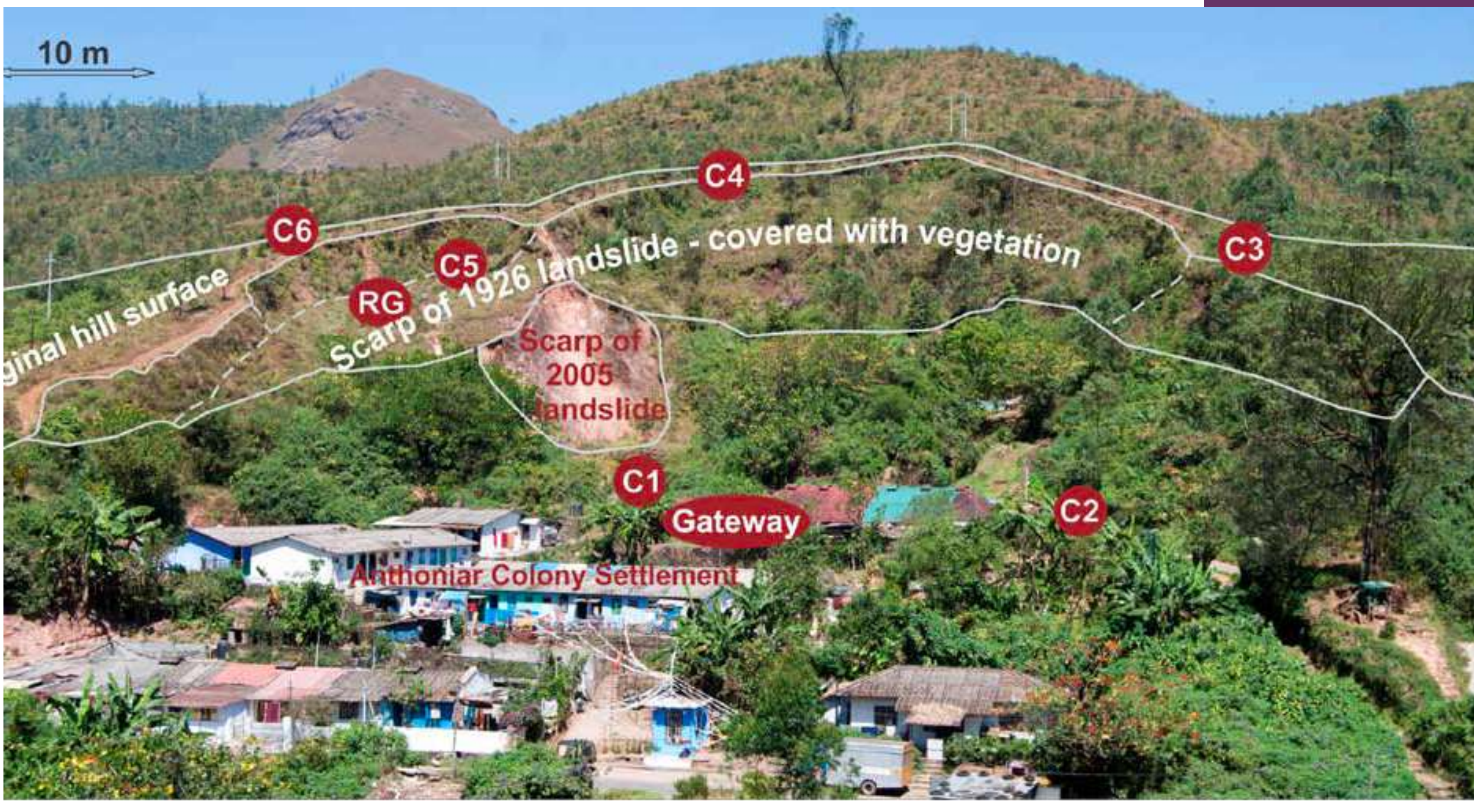
- **The first one occurred in 1926.**
  - **It was a massive landslide with an estimated volume of 10^5 m^3.**
  - **The scarp has a concave curvature.**
- **The second landslide occurred on 26 July 2005.**
  - **It was a complex rotational slide–debris flow with a volume of approximately 10^4 m^3 and was triggered by a torrential downpour.**
  - **The total rainfall recorded in Munnar on 26 July 2005 was 451mm. The same downpour also triggered two other landslides in the vicinity**

Wireless Deep Earth Probe

- Geophysical sensors
  - Wired
  - High Maintanence
- Wireless Sensor Networks
  - Commercially available wireless sensor nodes do not have the geophysical sensors such as
    - Rain gauge
    - Moisture sensor
    - Pore pressure sensor
    - Strain gauge
    - Tilt meter
    - Geophone
- Geophysical sensors are interfaced with the wireless sensor node through an
  - Interfacing circuit
  - Data acquisition board

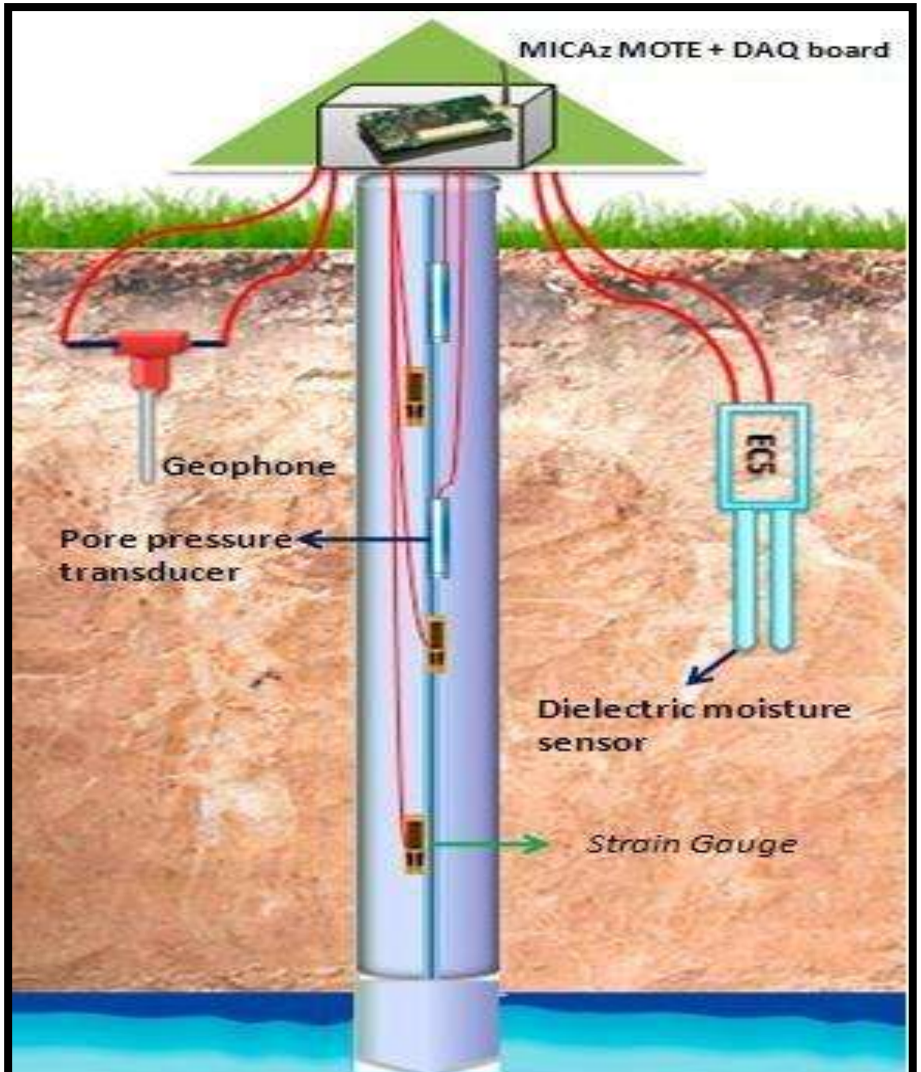


Locations of the Deep Earth Prob (DEPs) and Rain Gauge (RG)



WSN Monitoring & Warning Syst

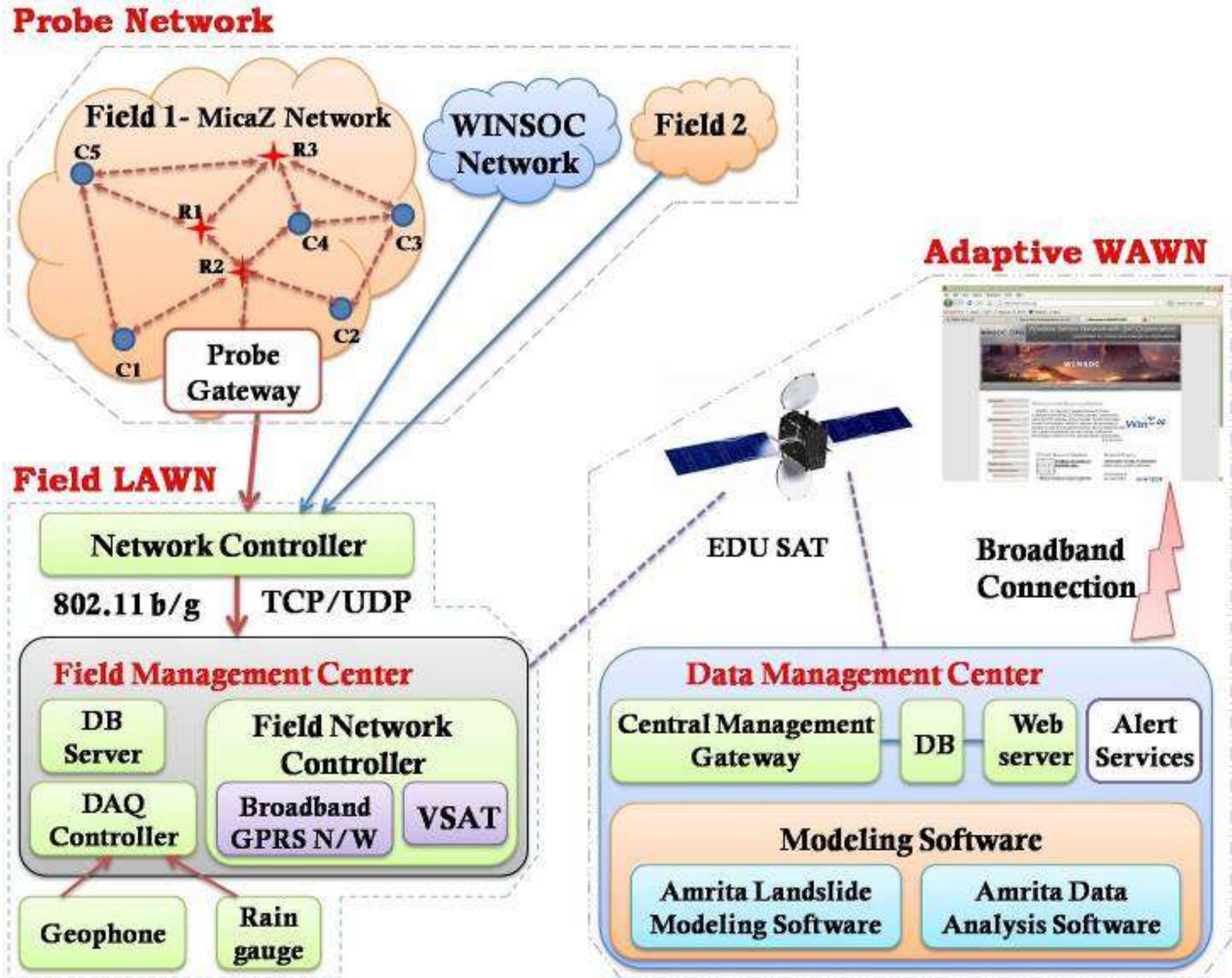
24/7 operational Landslide Monitoring & Detectio



- 20 Deep Earth Probes (DEPs) (maximum 23 meter deep)

- 150 geophysical sensors deployed
  - Pore Pressure transducers
  - Strain gauges
  - Tilt meters
  - Dielectric moisture sensor
  - Geophone
  - Rain gauge
- 20 wireless sensor nodes

Overall System Architecture



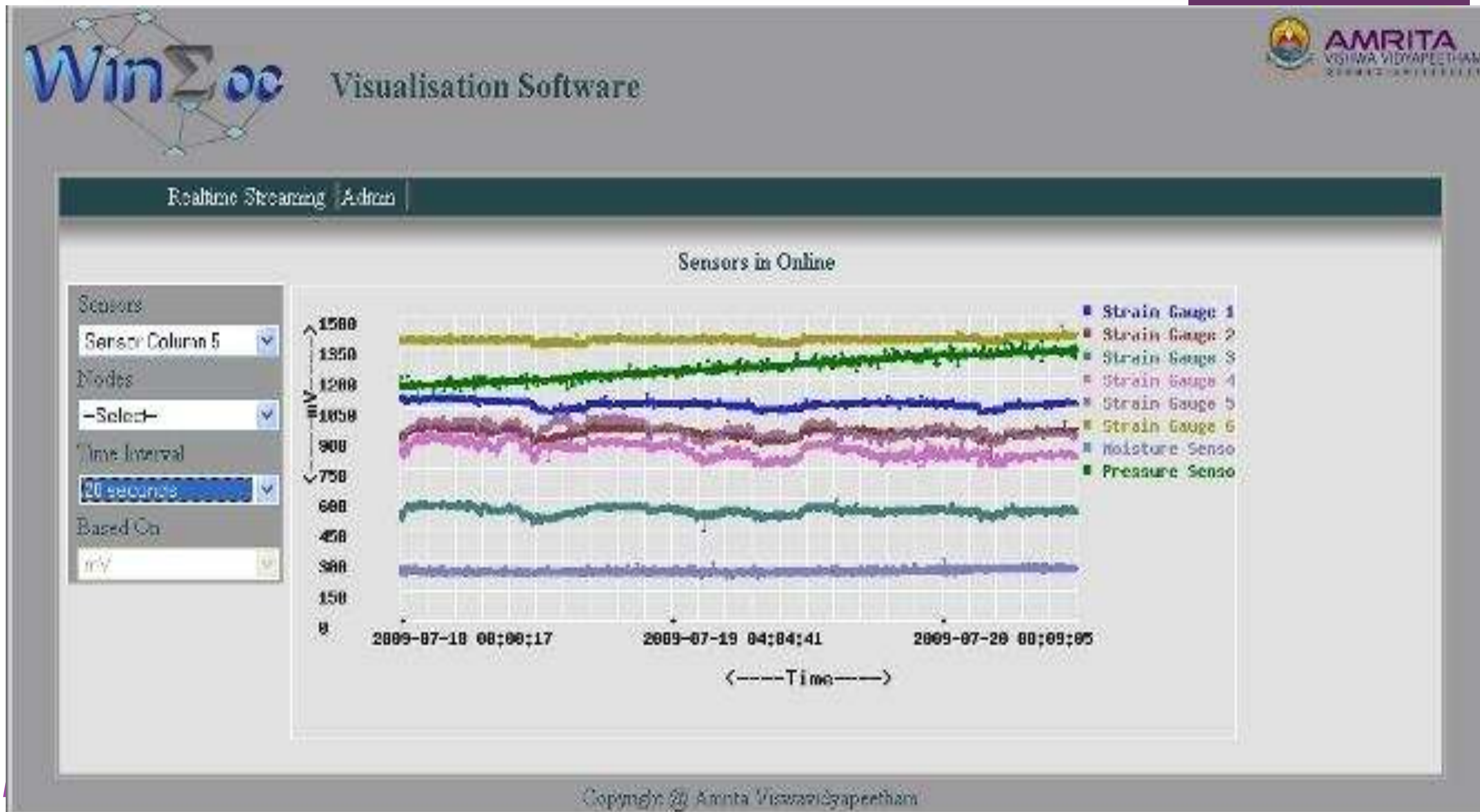
Warning system

- Real-time Data Analysis - Three Level Warning System
  - Warning 1: Threshold level of rain gauge & dielectric moisture sensor
  - Warning 2: Threshold level of pore pressure transducer
  - Warning 3: Detection of movement initiation
- Landslide Modeling Software
- Landslide Laboratory Setup

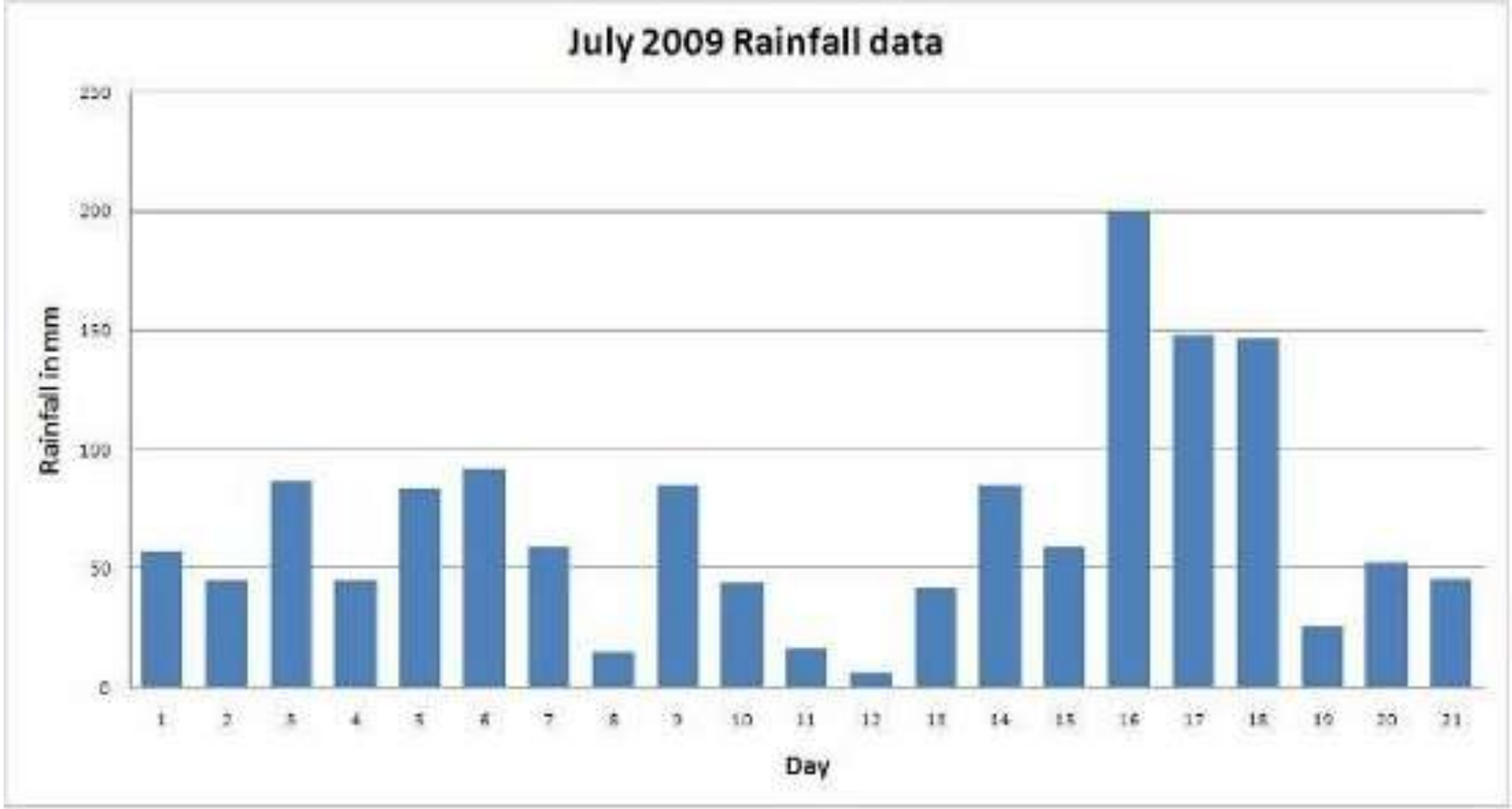
Design of Feedback System

- Remote administering,
  - the sampling rate of the geological sensors
    - with respect to real-time climatic variations,
  - monitor the level of battery charges,
  - monitor the level of solar charging rate,
  - indicate faulty wireless sensor nodes or geological sensors etc.

First Landslide Warning Issued in July 2009



Landslide Warning Issued



Landslide Warning Issued

- July 21, 2009
- Heavy rain fall
- Increase in pore pressure
- Slight movements
- Rainfall threshold exceeded with respect to Caine (1980)

$$I = 14.82D^{-0.39}$$

Landslide laboratory set up

Medium scale laboratory set up

- Medium Scale Laboratory Set up
  - 2m long by 1 meter wide by 0.5 m tall and holds around 0.6 m^3 of soil
  - Slope angle can be varied from 0 degree to 45 degree
  - Rainfall Simulator – Accurate raindrop size distribution and velocity
  - Seepage Simulator – Various infiltration rate

Large scale landslide laboratory set up

- 4.6 m long by 2.6 m wide by 2 m tall
- designed to hold approximately 12 m^3 of soil.
- up to 24 tone's of soil can be tested, at a maximum depth of up to 4 feet
- Slope angle can be varied from 0 degree to 45 degree
- Rainfall Simulator - Accurate raindrop size distribution
- Seepage Simulator - Various infiltration rate

Funding Agencies

- Partially funded by the WINSOC project, a Specific Targeted Research Project (Contact Number 003914) co-funded by the INFSO DG of the European Commission within the RTD activities of the Thematic Priority Information Society Technologies
  - 11 partners from 8 different countries

- Partially funded by Department of Information Technology (DIT), India with the project title as "Wireless Sensor Network for Real-time Landsldie Monitoring"

- Partially funded by Department of Science and Technology (DST), India with the project title as "Monitoring and Detection of Rainfall Induced Landslide using an Integrated Wireless Network System"

- Partially funded by Ministry of Earth Science (MoES), India with the project title as "Advancing Integrated Wireless Sensor Networks for Real-time Monitoring and Detection of Disasters"

Publications

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Research Initiatives

- The State Government & Disaster Management Departments has requested us to expand the wireless sensor network installation to other landslide prone areas in future major regions all over India:
  - Maharashtra State,
  - Kerala State,
  - the North Eastern region, and
  - the Himalayan region

Drought Forecast and Alert System [2]

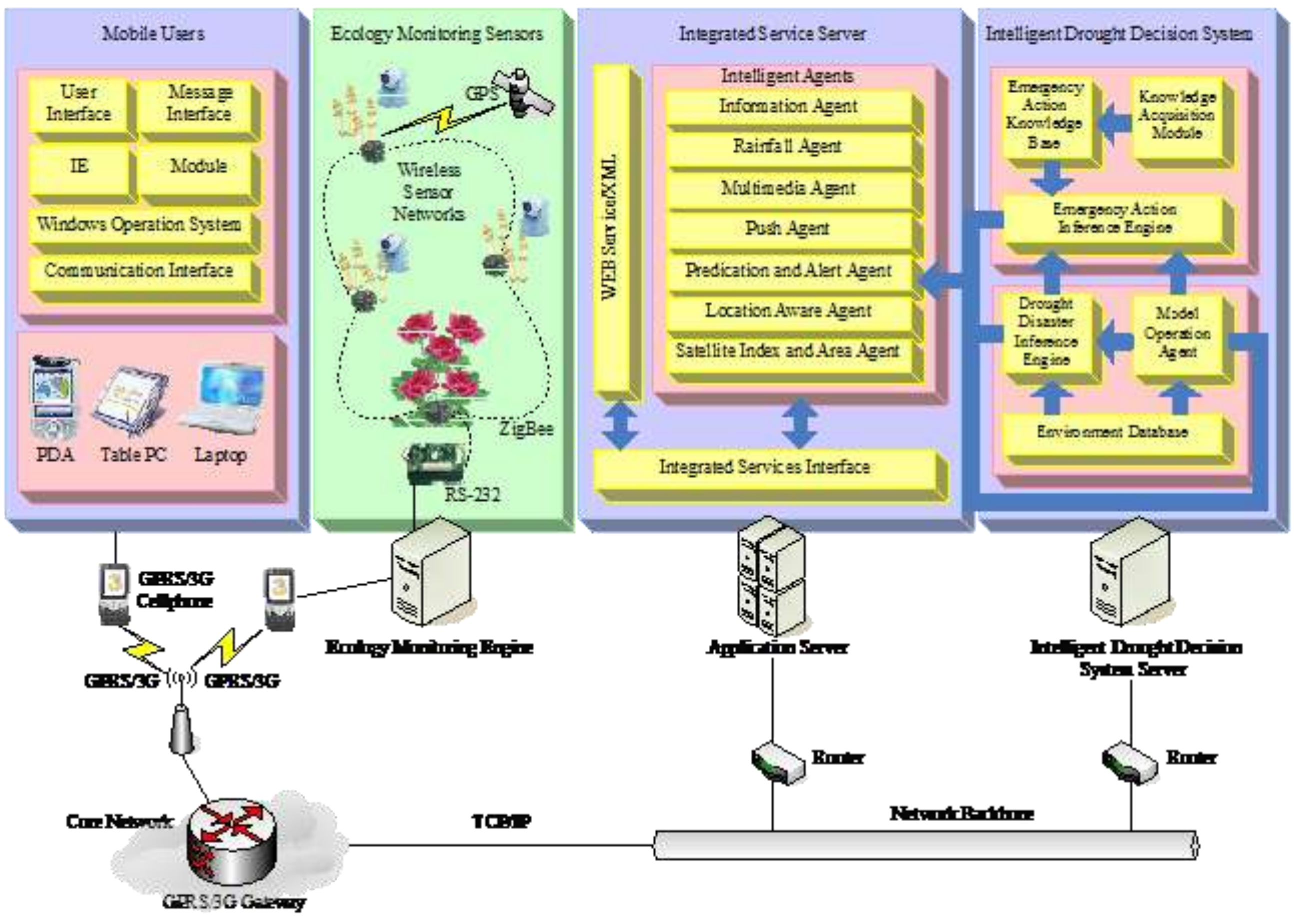
Drought

- Meteorological drought refers to the drought caused by abnormal climate and maladjusted rainfall.
- Hydrological drought indicates that there is no enough water supply for various applications due to water shortage in ground surface, such as lower water level of river or reservoir.
- Agricultural drought indicates that crops cannot grow normally due to insufficient soil moisture caused by water shortage within a certain period of time.
- Therefore, DFAS takes the rainfall and soil moisture as major variables for drought identification and monitoring covering meteorological and agricul- tural drought.

DFAS

- identification and monitoring of meteorological and agricultural drought
- Major Parameters and Sensors
- Rainfall → Rainfall sensor
- Moisture → soil moisture sensor

Drought forecast and alert system and network architecture

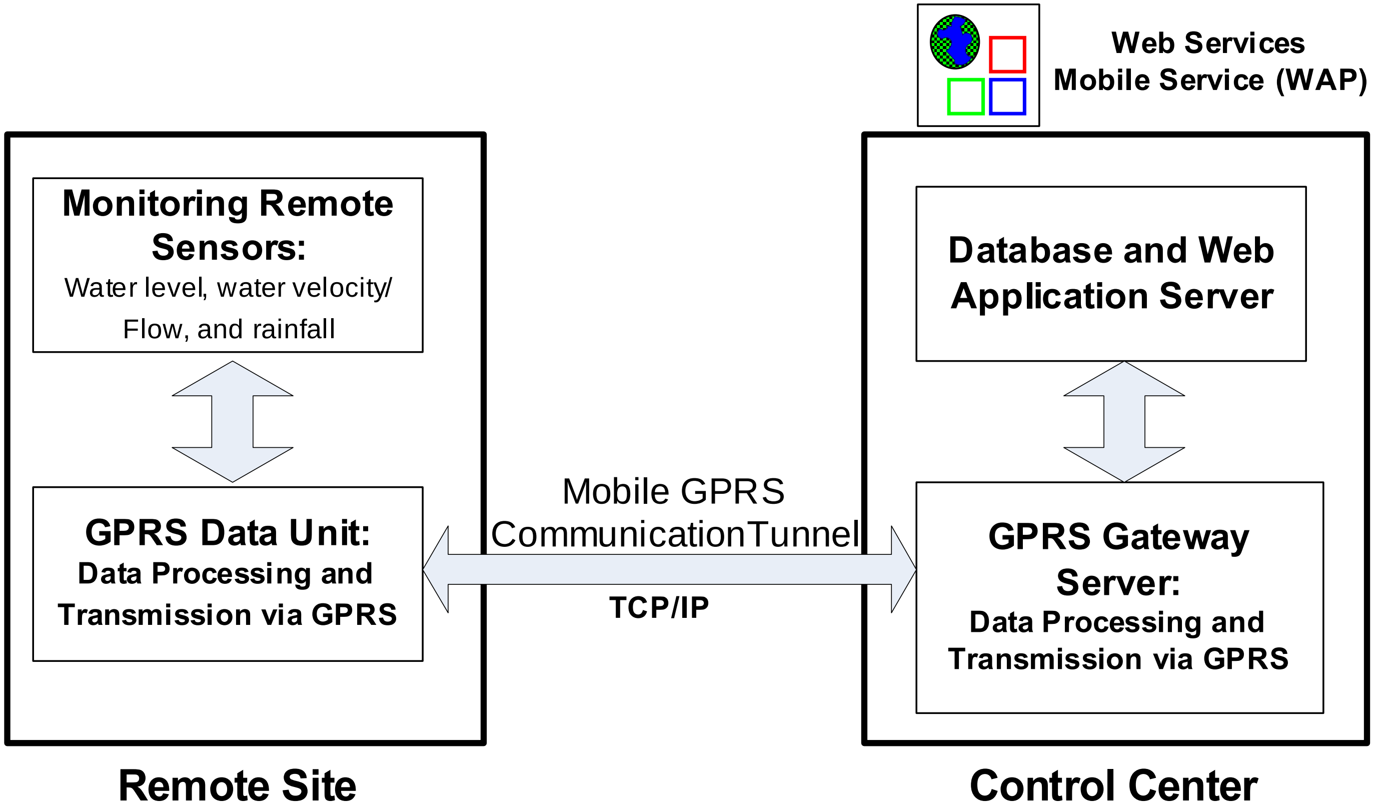


Real-time flood monitoring and warning system

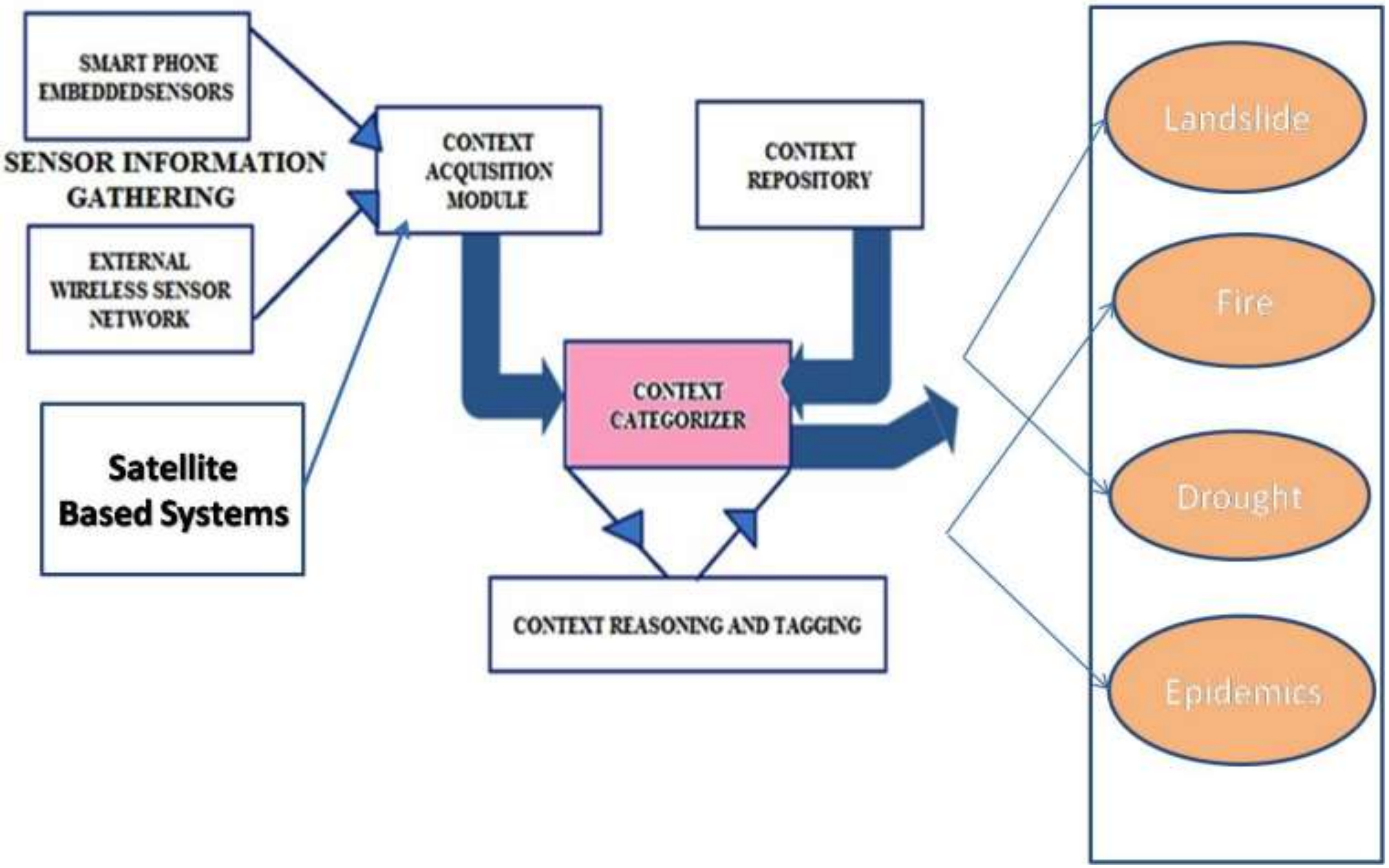
Sensing Parameters

- The system for real-time monitoring of water conditions:
  - water level
  - flow
  - precipitation level
- This system was developed to be employed in monitoring flood in Nakhon Si Thammarat, a southern province in Thailand

Architecture



Ubiquitious Mult-Context Model



Requirements Multi--Context System

- Context Aware System
- Location Based System
- Context Classification
- Heterogeneous Data Aggregation
- Adaptive Alert System

Monitor and Detect major disasters

Monitor and Detect other multiple types of disasters instigated by the major disaster

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Thank You