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IP4 Theme
Disruptive Technologies for Distributed Infrastructure and Sensing Society through IoT

UC University of Canterbury · The University of Auckland · Resilient Organisations · GNS Science · Massey University · Victoria University of Wellington · The University of Waikato · BRANZ

IP4 Research Questions

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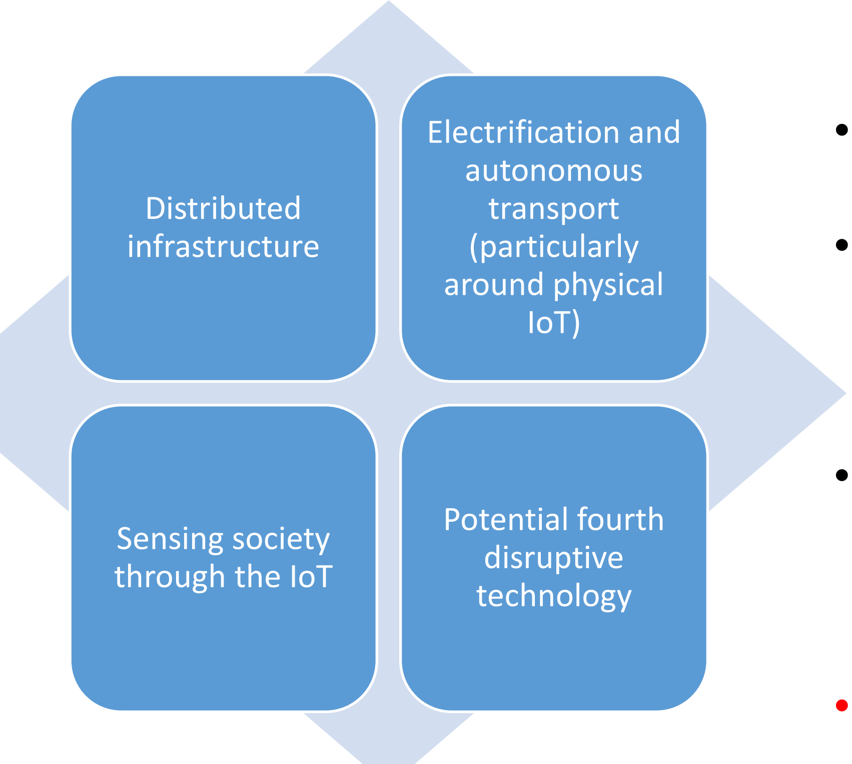

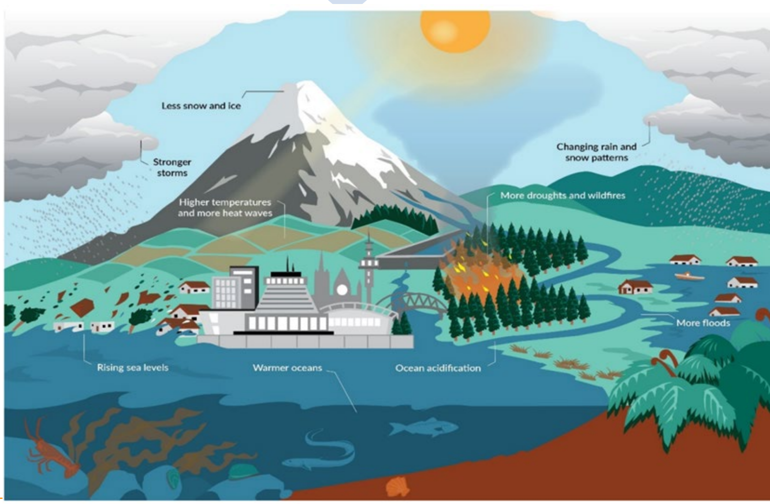

- **What is the failure hierarchy of a renewable distributed energy system in seismic events?**
- **How should existing asset management investment occur to provide resilience during the transition to a renewable and distributed energy system?**
- **How can real-time sensing enable early detection of network degradation pre-event, and situational awareness in the immediate post-event environment for rapid restoration?**
- **How do individual utility networks develop resilience to externality risks and avoid contagion?**
- **How does the trade-off in electrification of transportation, reducing vulnerable reliance on liquid fuels, but increasing resilience requirements for electricity, play out over time?**
- **How will autonomous transportation modes function in a beyond business-as-usual environment? (e.g. physically damaged roads, disrupted electrical systems)**

Need: Infrastructure NZ (2022-2052)

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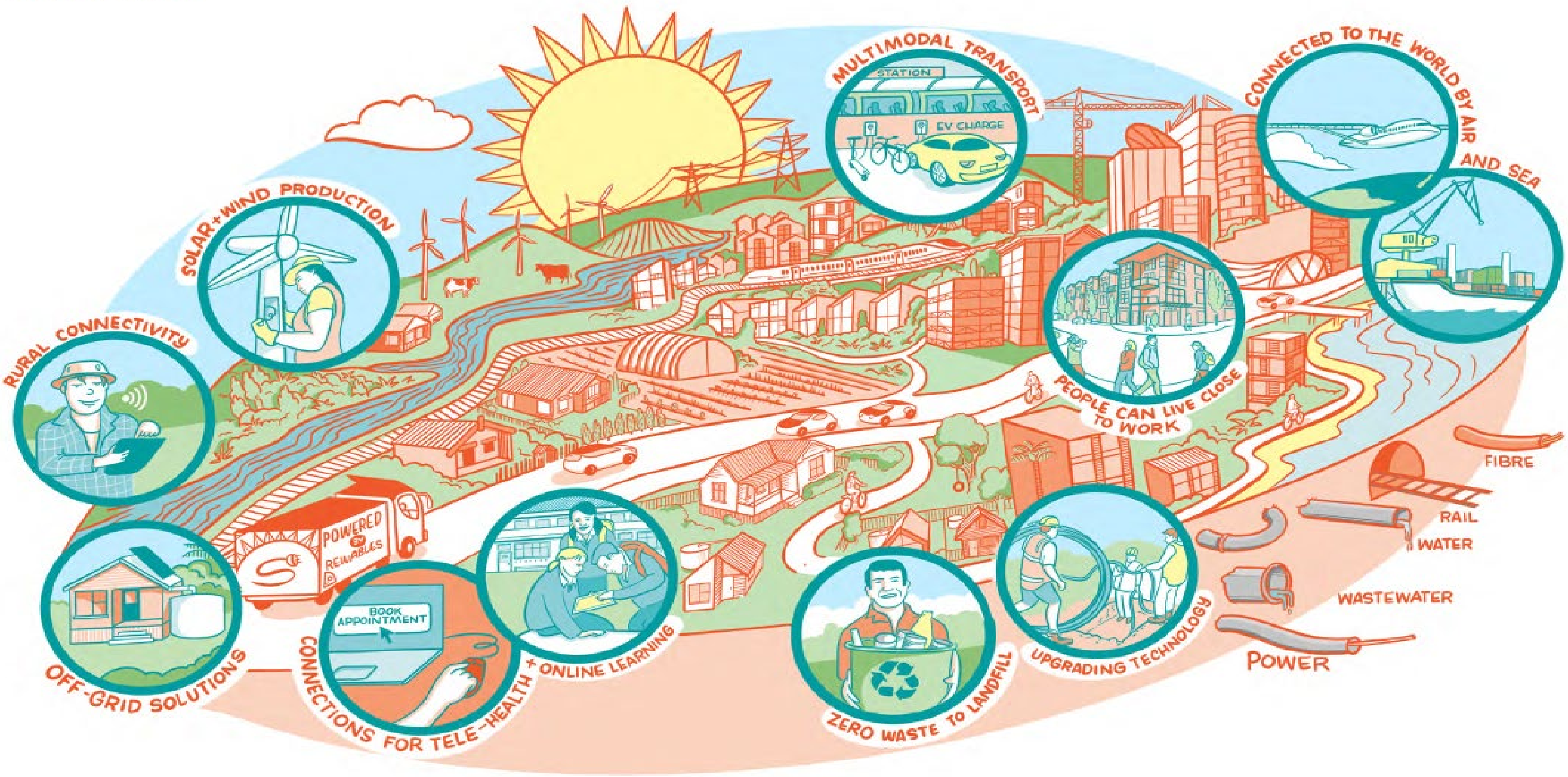
Infrastructure for a thriving
New Zealand



Rautaki Hanganga o Aotearoa
New Zealand Infrastructure Strategy | Te Waihanga
New Zealand Infrastructure Commission

Policy: Climate Change Adaptation

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Aotearoa New Zealand's adaptation strategy

Vision: Our people, places and systems are resilient and able to adapt to the effects of unavoidable climate change in a fair, low-cost and ordered manner

Purpose: To enable New Zealanders to prepare for and adapt to the impacts of climate change

Goals:
1. Reduce vulnerability to the impacts of climate change
2. Enhance adaptive capacity and consider climate change in decisions at all levels
3. Strengthen resilience to climate change

National climate change risk assessments and adaptation plans

Climate Change Commission	Government
2050: NZ Climate Change Risk Assessment 6	National adaptation plan 6: Due 2052
2044: NZ Climate Change Risk Assessment 5	National adaptation plan 5: Due 2046
2038: NZ Climate Change Risk Assessment 4	National adaptation plan 4: Due 2040
2032: NZ Climate Change Risk Assessment 3	National adaptation plan 3: Due 2034
2026: NZ Climate Change Risk Assessment 2	National adaptation plan 2: Due 2028
2020: NZ Climate Change Risk Assessment 1	National adaptation plan 1: Due 2022

Monitor and report on the implementation of national adaptation plans (every two years)

Report to UN climate change process (UNFCCC) – adaptation communication (every five years)

- Climate Change Commission
- Government

Enable New Zealanders to build resilience and adapt

Māori | Central government | Local government | Private sector | Individuals and communities

Our climate reality case studies

Adapting to flood risk in Westport
One in seven people across New Zealand already lives in areas prone to flooding

Wildfire preparedness at Mount Iron, Wānaka
Wildfire season projected to lengthen 70 per cent in 20 years

Growing kai under increasing dry-climate adaptation and the primary sector
Drought has cost New Zealand at least $720 million in economic losses over the last decade

Hawke's Bay and the Clifton to Tangoio Coastal Hazards Strategy 2120
At 1 metre of sea-level rise, 125,600 buildings could be exposed

The 2020 National Climate Change Risk Assessment identifies 43 priority risks New Zealand faces from the impacts of climate change. These risks will affect all communities and all sectors and include risks to our ecosystems, wellbeing, economy, infrastructure and governance.

2022 National adaptation plan 1

This national adaptation plan will:
1. Reform institutions to be fit for a changing climate
2. Provide data, information and guidance to enable everyone to assess and reduce their own climate risks
3. Embed climate resilience across government strategies and policies

Outcome areas and objectives

Natural environment	Homes, buildings and places	Infrastructure	Communities	Economy and financial system
Ecosystems which are healthy and connected, and where biodiversity is thriving	Homes and buildings are climate resilient and meet social and cultural needs	Reduce the vulnerability of assets exposed to climate change	Enable communities to adapt	Sectors, businesses and regional economies can adapt; participants can identify risks and take action
Robust biosecurity reduces the risk of new pests and diseases spreading	New and existing places are planned and managed to minimise risks to communities from climate change	Ensure all new infrastructure is fit for a changing climate	Support vulnerable people and communities	A resilient financial system underpins economic stability and growth; participants can identify, disclose and manage climate risks
Support working with nature to build resilience	Māori connections to whenua and places of cultural value are strengthened through partnerships	Use renewal programmes to improve adaptive capacity	Support communities when they are disrupted or displaced	
	Threats to cultural heritage arising from climate change are understood and impacts minimised		The health sector is prepared and can support vulnerable communities affected by climate change	

System-wide outcome areas and objectives

Legislation and institutional arrangements are fit for purpose and provide clear roles and responsibilities	Robust information about climate risks and adaptation solutions is accessible to all	Tools, guidance and methodologies enhance our ability to adapt	Unlocking investment in climate resilience

Timeline: NZ Emission Reduction Targets

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Aotearoa New Zealand's emissions reduction plan

Ch. 1
Playing our part

Purpose: To contribute to the global effort to limit global warming to 1.5°C

Targets: Net-zero long-lived gases by 2050 and a 24–47% reduction in biogenic methane by 2050

Emissions budgets and plans	Nationally Determined Contributions
2046–50 Sixth emissions budget (set 2035) and emissions reduction plan (set 2044)	NDC 5 (2046–50)
2041–45 Fifth emissions budget (set 2030) and emissions reduction plan (set 2039)	NDC 4 (2041–45)
2036–40 Fourth emissions budget (set 2025) and emissions reduction plan (set 2034)	NDC 3 (2036–40)
2031–35 Third emissions budget (set 2022) and emissions reduction plan (set 2029)	NDC 2 (2031–35)
2026–30 Second emissions budget (set 2022) and emissions reduction plan (set 2024)	Nationally Determined Contribution 1 (2021–30)
2022–25 First emissions budget (set 2022) and emissions reduction plan (set 2022)	

Ch. 2 **Empowering Māori** | Ch. 3 **Equitable transition** | Ch. 4 **Working with nature**

A productive, sustainable and inclusive economy

System settings:
- Ch. 5 Emissions pricing
- Ch. 6 Funding and finance
- Ch. 7 Planning and infrastructure
- Ch. 8 Research, science, innovation and technology
- Ch. 9 Circular economy and bioeconomy

Sector plans:
- Ch. 10 Transport
- Ch. 11 Energy and industry
- Ch. 12 Building and construction
- Ch. 13 Agriculture
- Ch. 14 Forestry
- Ch. 15 Waste
- Ch. 16 Fluorinated gases

Thriving households

WHAT'S UNDERWAY

- More than 1,100 electric vehicle (EV) chargers co-funded across Aotearoa with more to come.
- The Clean Vehicle package has helped triple monthly EV sales.
- The Warmer Kiwi Homes initiative helps fund heating and insulation upgrades for low-income households.
- The National Policy Statement on Urban Development to allow more housing close to urban centres and rapid and active transport routes.

WHAT'S COMING

- Most urban households to have access to a food waste collection service by 2030.
- All municipal landfills to have landfill gas capture systems by 2026.
- Zero-emissions public bus mandate established by 2025.

OUR GOALS

- The total distance travelled by the light fleet (cars, vans, utes) is reduced by 20 per cent by 2035.
- Zero-emissions vehicles are 30 per cent of the light fleet by 2035.
- Improved insulation standards mean new buildings are warmer and drier and require 40 per cent less energy to heat.
- Faster, frequent and convenient buses and trains and safe walkways and cycle lanes through our cities.

WHAT'S UNDERWAY

- Multi-million-dollar co-investment in industry decarbonisation and economic growth.
- Mandatory climate-related risk reporting for listed companies and financial institutions.
- New Zealand Green Investment Finance to accelerate investment in our low-carbon future.
- End to new offshore fossil fuel exploration.

WHAT'S COMING

- Embed Te Tiriti, mātauranga Māori, and Māori aspirations in our research, science and innovation system through the Vision Mātauranga policy.
- Grow research and development spending across Aotearoa to 2 per cent of GDP by 2030.
- Use climate innovation platforms to drive the discovery and adoption of new clean technologies.
- Develop an energy strategy by the end of 2024.

OUR GOALS

- Aotearoa has a circular economy with a thriving bioeconomy by 2050.
- Half of all energy we use is from renewable resources by 2035.
- Incorporating mātauranga Māori supports better decision-making throughout the climate response.

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Generation and Integration Solar Power Into Smart Grid

Rizki Rahayani

Background : Hazard Risks

Natural Hazards

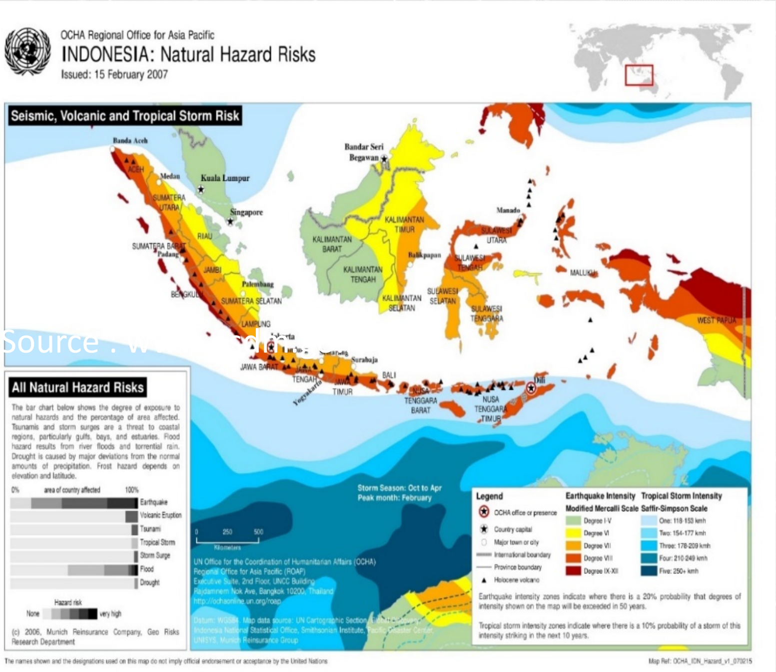
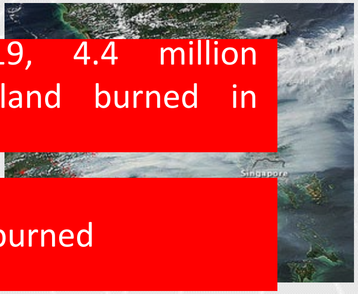


Figure 6. Indonesian Natural Hazard Map

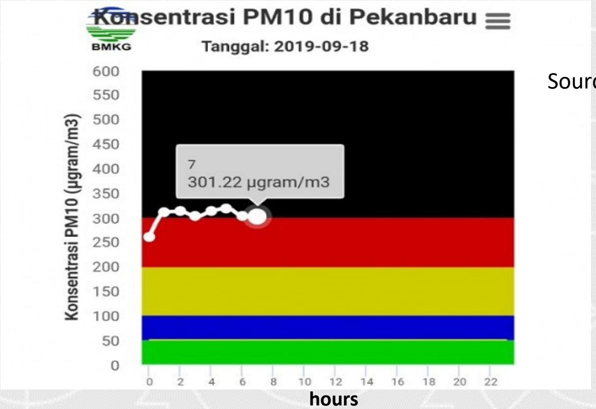
Source : [UN Office for the Coordination of Humanitarian Affairs]

Human Made Hazards



2015 – 2019, 4.4 million hectares of land burned in Indonesia

18% repeadly burned



Source : BMKG

Figure 7. Forest Fires in Indonesia

PhD Research Questions

Research Questions
1. Does haze from forest fire affect significantly in solar power generation ?
2. How much solar energy can be generated during forest fires ?
3. How to select optimum location for solar power plant with minimum loss from forest fire effect?
4. How to support electricity data transmission from/to power plant ?

Objectives

Objectives for optimization of solar power generation and integration in Indonesia

Solar Power Generation

- Solar irradiance forecasting during forest fires
- Solar power plant site planning based on historical hazards location

Solar Power Integration

- Communication planning from/to solar power generator

Methodologies & Approach

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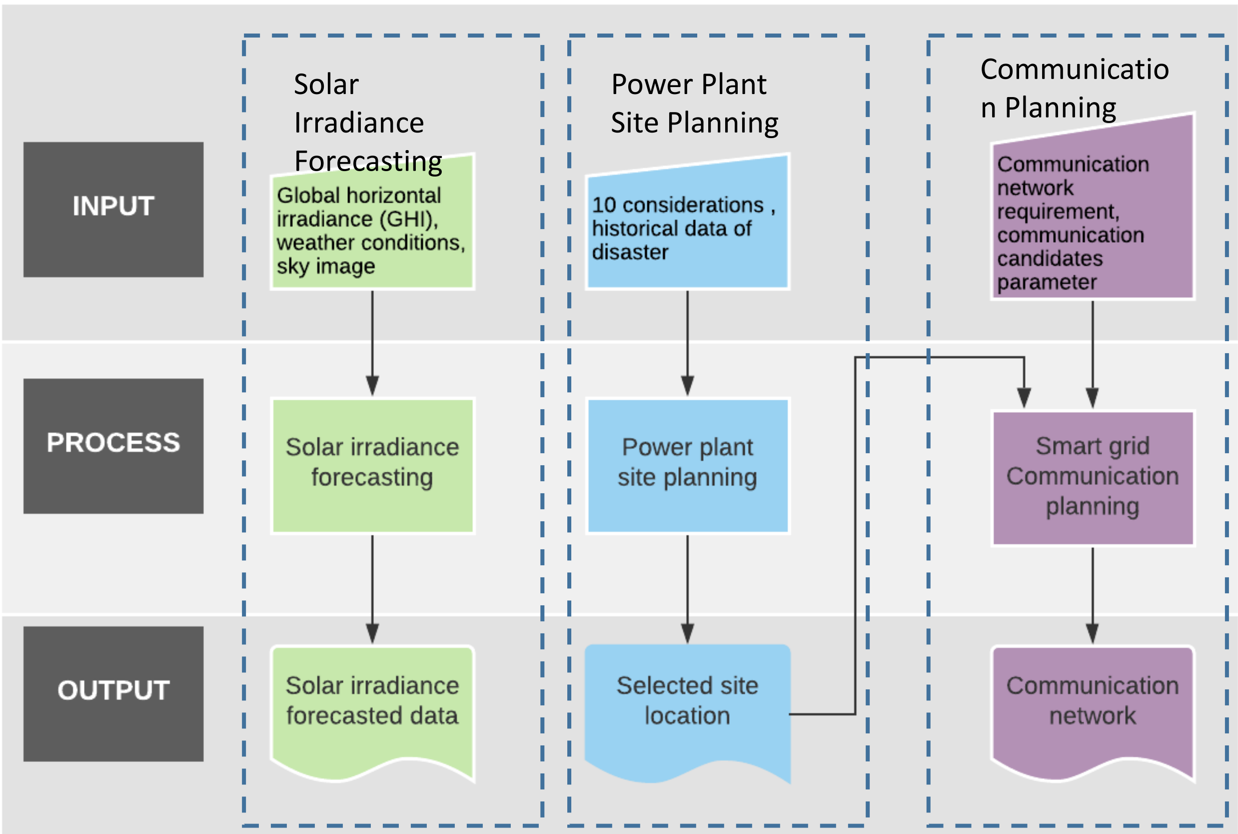

Figure 8. Solar Irradiance Forecasting Framework

Solar Irradiance Forecasting

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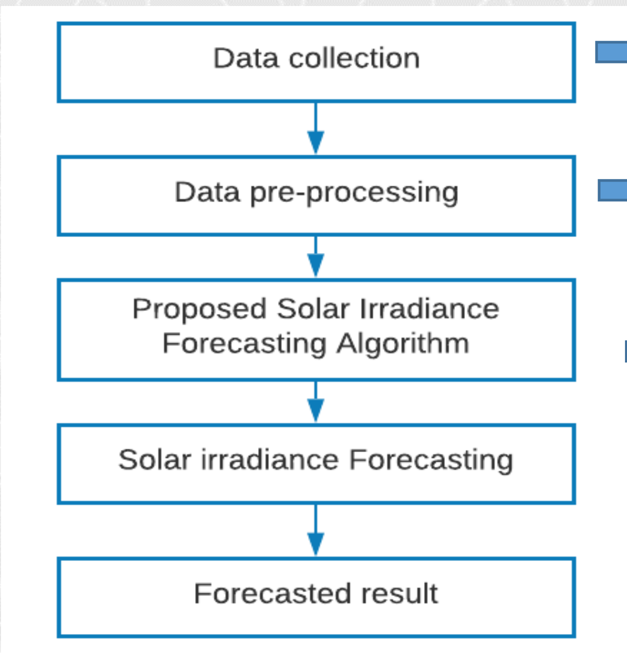

Figure 9. Solar Irradiance Forecasting Framework

Possible challenges

Possible solutions

Evaluation of Accuracy Level

- *normalized root mean square error* (nRMSE) to observe the error between forecasted results and data observed.

$$nRMSE\ (\%) = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}}{\frac{1}{n}\sum_{i=1}^{n} y_i} \times 100$$

Hybrid methods : MLP, sky imagery & weather prediction

- *normalized mean bias error* (nMBE) to calculate the systematic under or over forecast.

$$nMBE\ (\%) = \frac{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)}{\frac{1}{n}\sum_{i=1}^{n} y_i} \times 100$$

Power Plant Site Planning

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MCDM Parameters

1. Solar radiation
2. Sunshine radiation
3. Air temperature
4. Proximity to power grid
5. Proximity to road infrastructure
6. Proximity to residential
7. Land aspects
8. Historical hazard risk

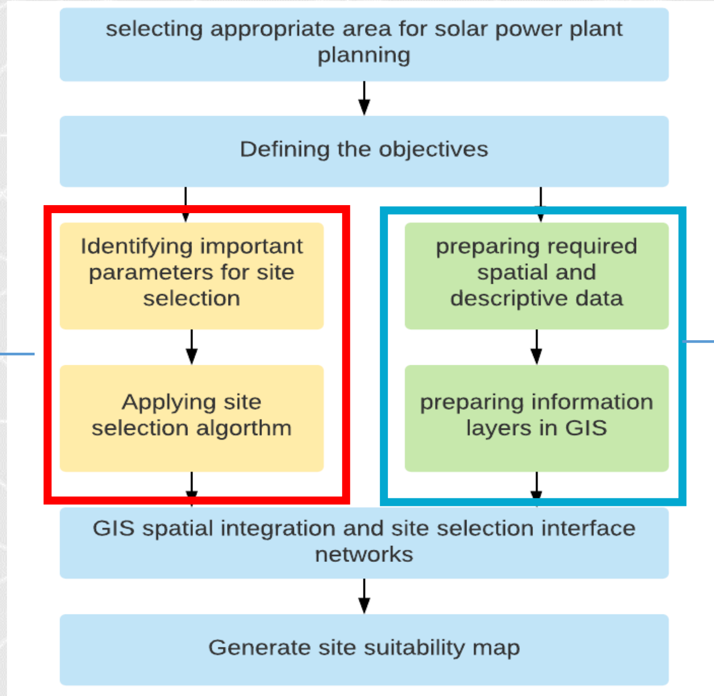

Figure 11. Solar Power Plant Site Planning Framework

Define preferable city / province

Table 2. Data Requirement

Parameter	Data Source
GHI (kWh/m2)	Solargis website , solar irradiance forecasting results
Tem[illegible] (°C)	Solargis, BMKG
Relative Humidity (%)	BMKG
Elev[illegible]	[illegible]
Slope	[illegible]
Azim[illegible]	[illegible]
Road[illegible]	[illegible]c Works
Powe[illegible]	[illegible]
Dem[illegible]	[illegible]
Natu[illegible]	[illegible]nation of
Hum[illegible]	[illegible]

Define constraint layers based on
1
2
3

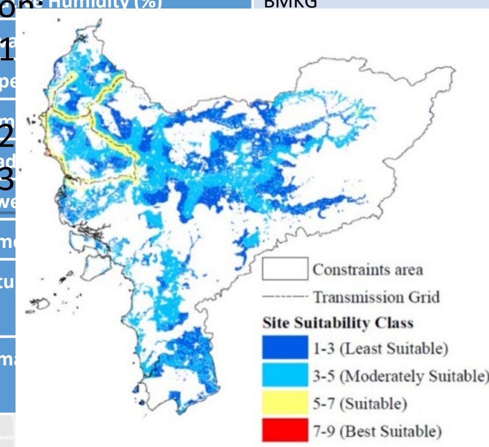

Figure 12. Example of Suitable Map

Communication Planning

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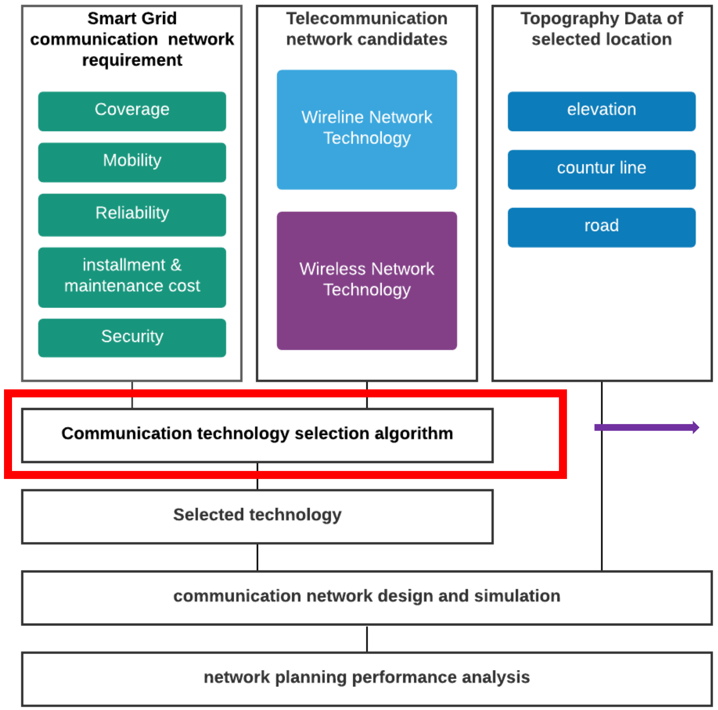

Figure 14. Communication Planning Framework

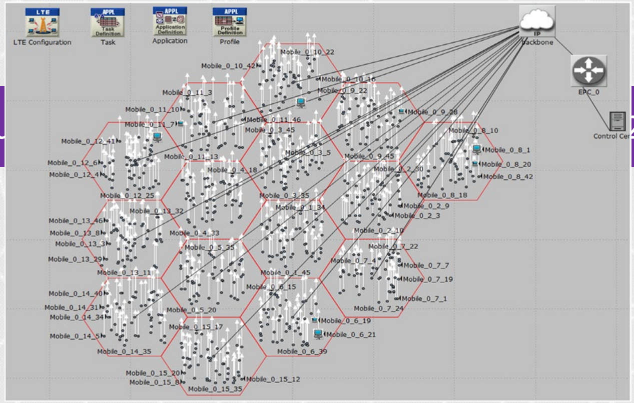

Figure 15. Example of Communication Planning in Network Simulator

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Communication, Seismicity and Resilience

Eric Sauvage

Seismic Resilience Evaluation of Fixed Communication Infrastructure Systems

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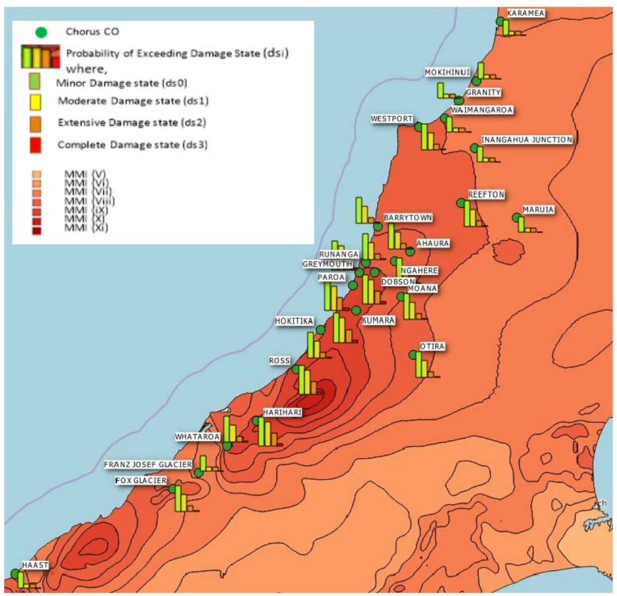
Farrukh Latif

- Assessment of the impact of major earthquake on the physical infrastructure of fixed communication

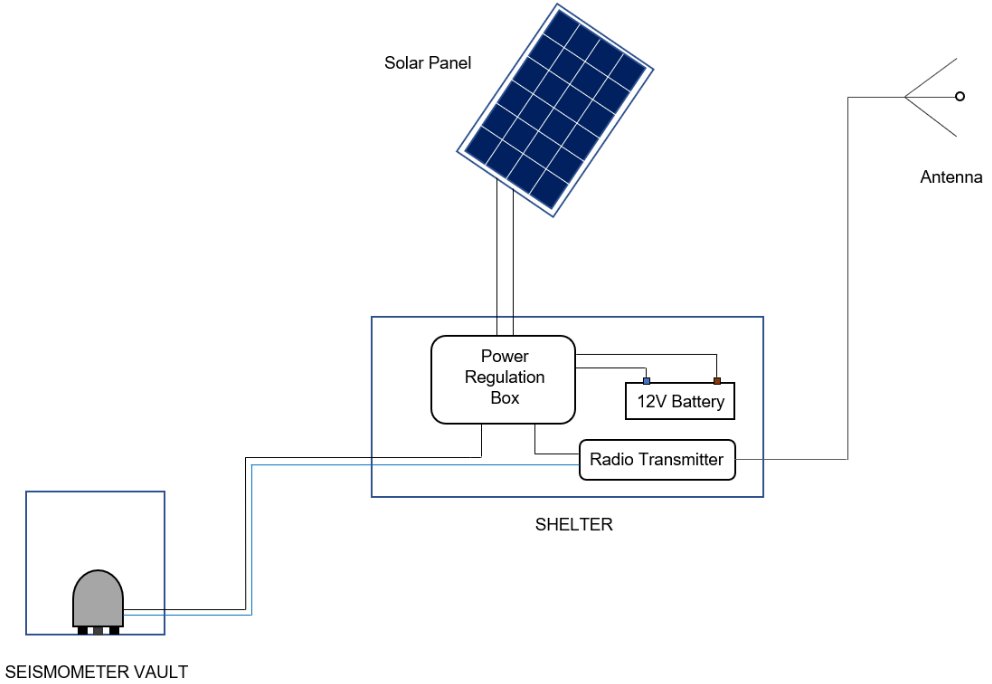


[Central offices Damage risk quantification for AF8 Central hypocenter]

- Evaluation of the seismic resilience of fixed communication system
- Guidelines for seismic resilience enhancement

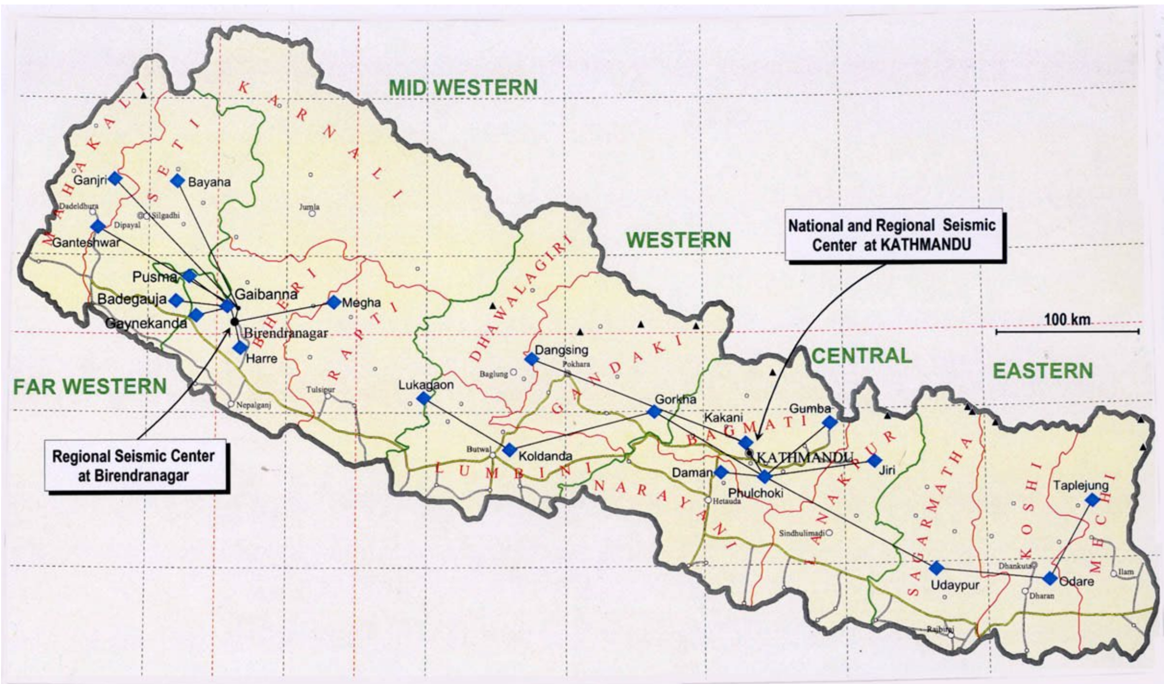
Telecommunication for Seismic monitoring

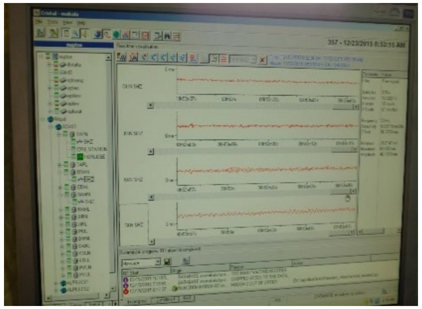
Seismometer



Energy
(+ Transmission)

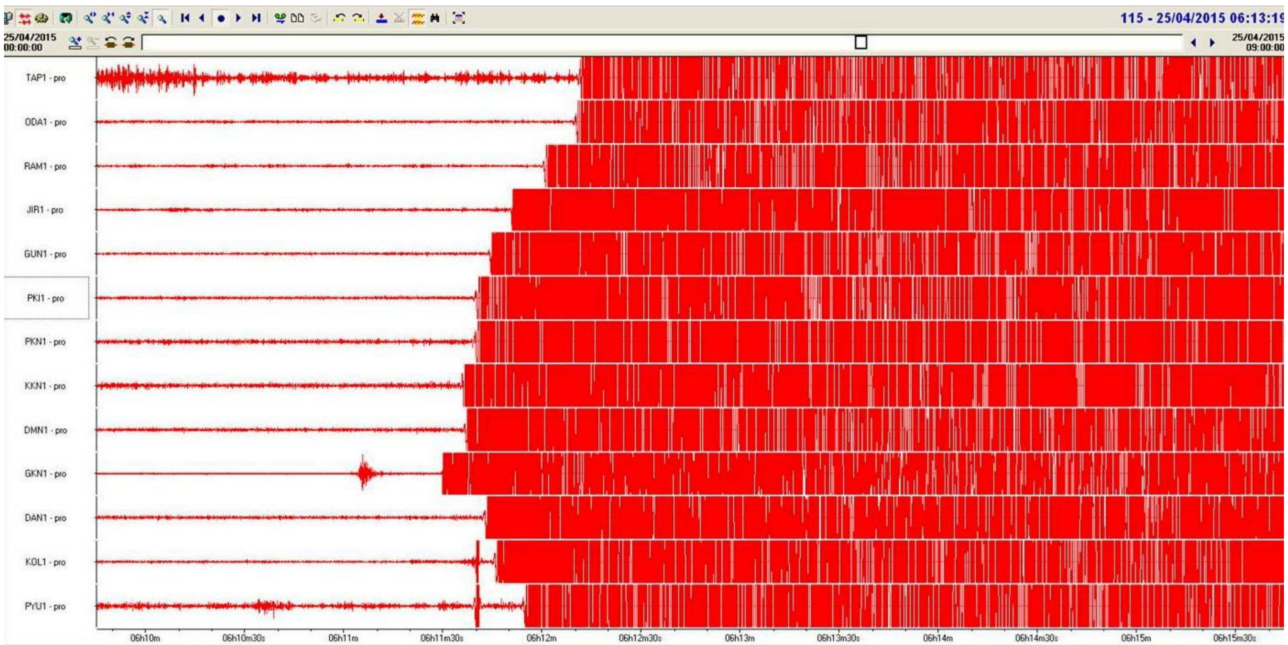
Acquisition and Processing





[The seismic network in Nepal]

Occurrence of an extreme event



Seismic signals for the Gorkha-Nepal Earthquake, M_L=7.6 (25/04/2015)

Challenges and questions

How can real-time sensing enable early detection of network degradation pre-event, and situational awareness in the immediate post-event environment for rapid restoration?

How to define resilience for the telecommunication network and infrastructure?

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Resilience supporting technologies for distributed renewable energy systems during High-Impact Low Probability (HILP) Events

Xin Liu

Phasor estimation algorithm

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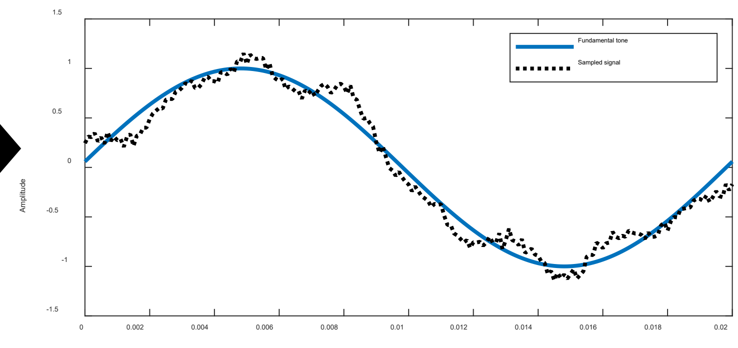
Synchrophasor: measurement of the **phasor** of the fundamental tone composing a periodic waveform of an electric quantity (i.e., voltage, current) using a **common time reference**.

The core of PMU is the **algorithm** that estimates frequency, amplitude, and phase of the main frequency component.

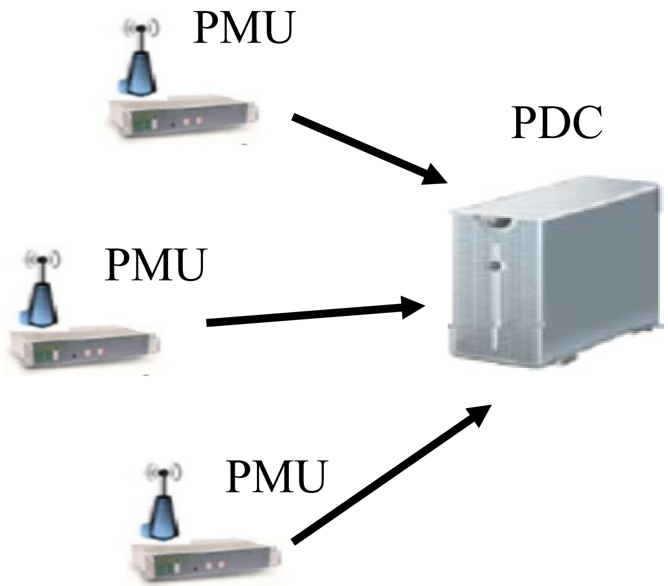
<u>Fundamental concepts:</u>
Extraction of the fundamental tone with a distorted signal of finite length
Identification of its Amplitude, Phase and Frequency.



In real world, the sampled signals are always distorted and with time-varying parameters.

Challenges and questions

What is the failure hierarchy of a renewable distributed energy system in seismic events?
How should existing asset management investment occur to provide resilience during the transition to a renewable and distributed energy system?



Identification of possible pre-event of network degradations :

- switch actions,
- disconnection of distributed generation,
- frequency events,
- machine learning based event and fault detection and localization,
- machine learning based optimal network topology,

etc…

Phasor measurement unit (PMU): A device used to estimate the magnitude, phase, frequency, and rate of change of frequency using a common time source.

Phasor data concentrator (PDC): A data concentrator used in phasor measurement systems.

Sensor resilience

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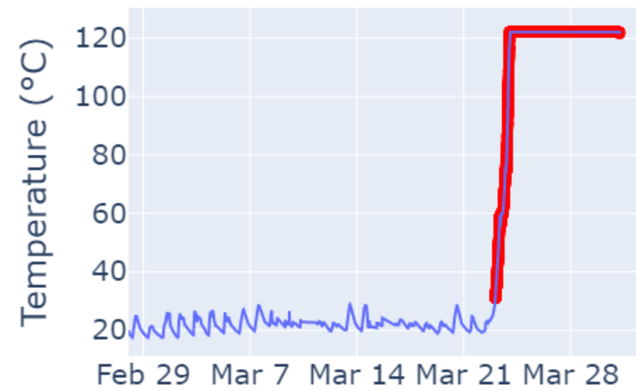
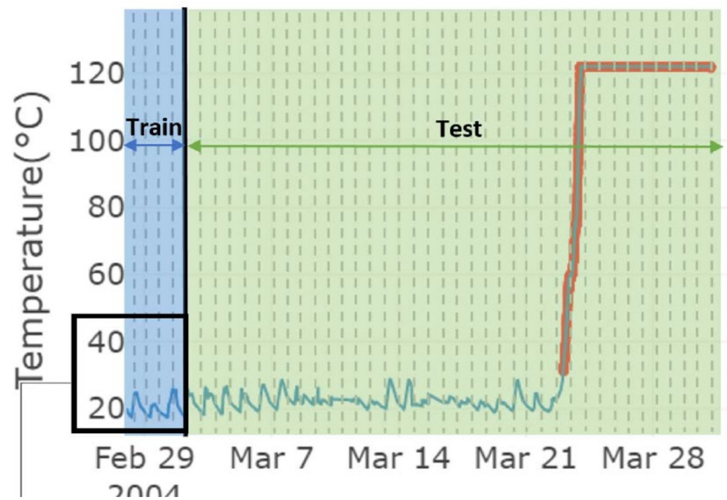
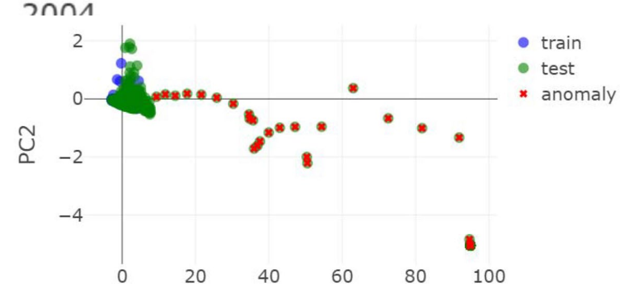
- Machine learning or data processing outcomes are heavily dependent on sensor data quality
- Sensor data may suffer from many uncertainties
  - Environmental factors
  - Sensor failure/drift
  - Power failure
- Challenges
  - Human intervention is not feasible
  - Sensor heterogeneity
- Automated sensor anomaly detection is necessary to realise a full potential distributed sensing system







Kevin Wang, University of Auckland

Situational awareness

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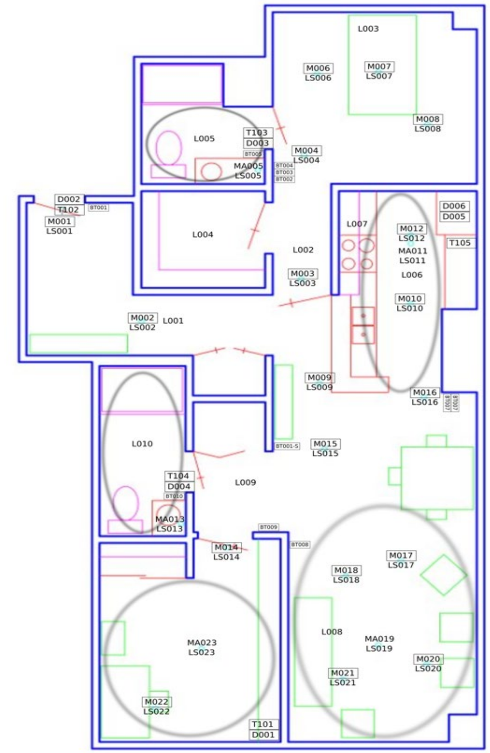
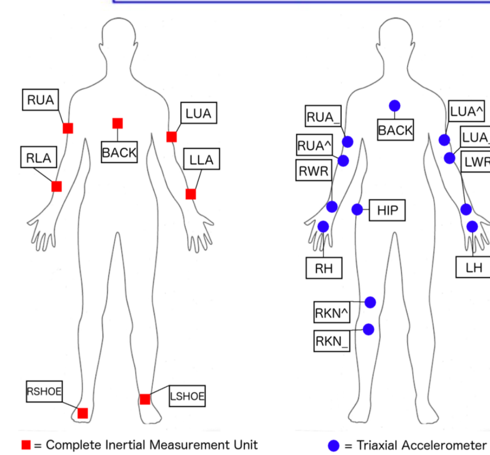
- Wearable and ambient sensors are able to provide contextual information for identifying various types of situations or activities, e.g.,
  - Outdoor/indoor human activities
  - Driving behaviour
- The knowledge of alike situations/activities is not necessarily transferrable
  - Different ways of deployment
  - Different types of sensor
- Challenges
  - Limited amount of sensor data
  - Lack of in-situ observation
- Robust situational awareness can be achieved through crowdsourcing and distributed machine learning and knowledge sharing





Kevin Wang, University of Auckland

Distributed monitoring & control

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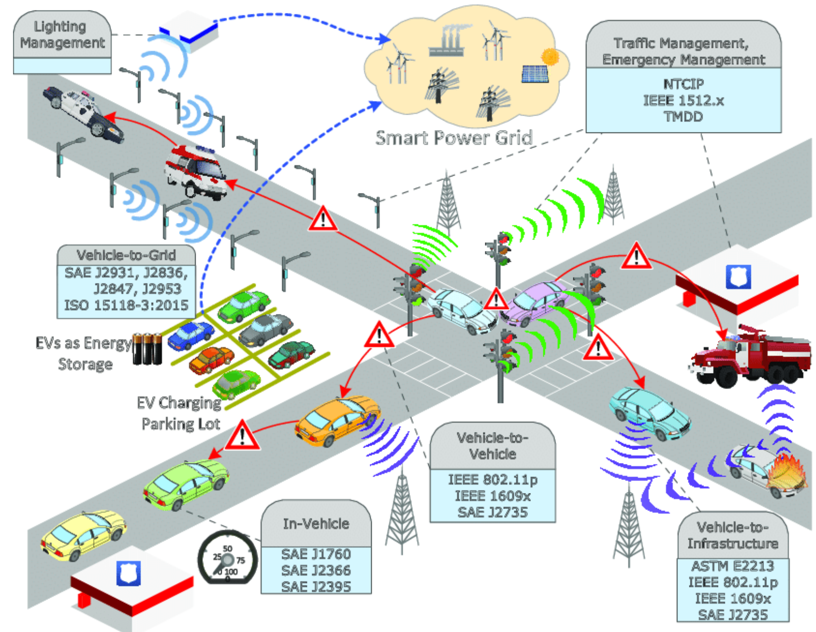
- Future IoT-based systems will be geographically distributed
  - Smart city monitoring
  - Intelligent/Electrical/Autonomous transportation
- Highly complex network environment with mobile devices
  - Utility/Teleco/Traffic network
- Challenges
  - Dynamic and real-time events
  - Conflicting priorities
- Dynamic load balancing and resource allocation is necessary to ensure resilient and well performing network



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Strategic adoption of tech
Resilience gain
Seismic resilience co-benefits

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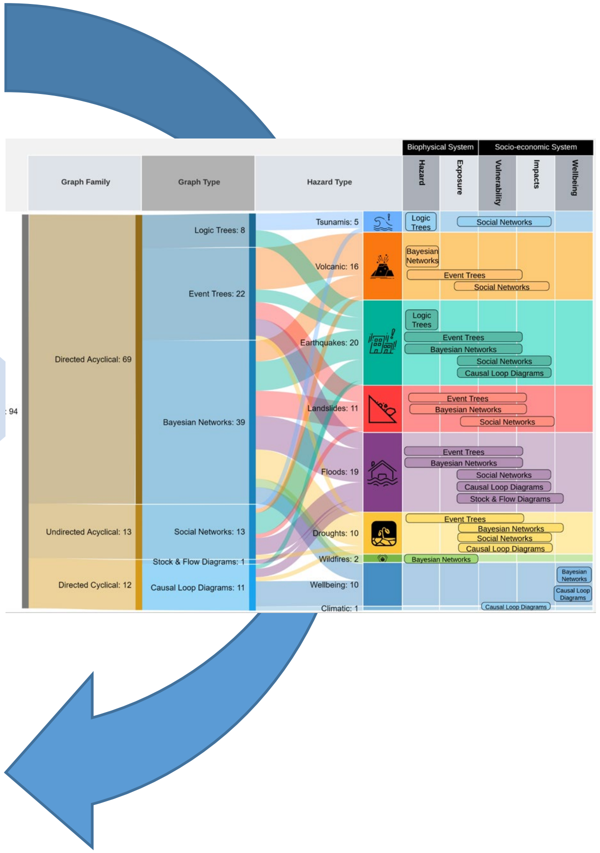

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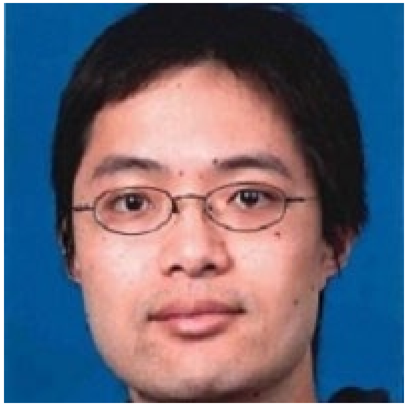
IP4 Theme: Disruptive Technologies for Distributed Infrastructure and Sensing Society through IoT

Check us out

https://wiki.canterbury.ac.nz/display/QuakeCore/IP4%3A+Harnessing+Disruptive+Technologies+for+Earthquake+Resilience

Get involved



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