# Project Title: Context-Aware Disaster Mitigation using Mobile Edge Computing and Wireless Mesh Network

Background :

Natural disasters occur frequently around the world. Internet of things (IoT) sensors can detect such cataclysmic events and initiate rescue actions. In existing IoT framework, data are transmitted to the remote cloud via wired connection for further analysis. Several issues remain to be addressed, including massive deployment effort, unavailability of vicinity communication infrastructure, data transfer over limited bandwidth, high latency in communication networks, and redundancy in disaster content.

Targets:

To develop a context-aware disaster mitigation system (CAMS) that utilizes mobile edge computing (MEC) and wireless mesh network powered by NerveNet. Specifically, the overall project goal can be divided into:

**GOAL 1 Edge-Level Disaster Detection**
**GOAL 2 Mesh-Network Database Synchronization**
**GOAL 3 Evacuation Route Strategy Optimization**

Speaker:

Ir. Dr. Tham Mau Luen @ Universiti Tunku Abdul Rahman, Malaysia

# Project Title: Context-Aware Disaster Mitigation using Mobile Edge Computing and Wireless Mesh Network

Project Members :

| Name | Institution | Name | Institution |
|---|---|---|---|
| **Ir. Dr. Tham Mau Luen** | UTAR, Malaysia | **Dr. Yasunori Owada** | NICT, Japan |
| **Ir. Dr. Chang Yoong Choon** | UTAR, Malaysia | **Dr. Goshi Sato** | NICT, Japan |
| **Ts. Dr. Ezra Morris** | UTAR, Malaysia | **Mr. Hachihei Kurematsu** | BHN Association/JTTA, Japan |
| **Dr. Lee Ying Loong** | UTAR, Malaysia | **Mr. Nobuyuki Asai** | Ready Affiliate Japan Co., Ltd, Japan |
| **Mr. Lim Wei Sean** | UTAR, Malaysia | **Prof. Myint Myint Sein** | UCSY, Myanmar |
| **Mr. Teoh Han Wei** | UTAR, Malaysia | **Prof. Thin Lai Lai Thein** | UCSY, Myanmar |
| **Ir. Dr. Nordin Bin Ramli** | MIMOS, Malaysia | **Prof. Zin May Aye** | UCSY, Myanmar |
| **Dr. Tuan Ahmad Zahidi Tuan Abdul Rahman** | MIMOS, Malaysia | **Ms. Emmon Maw** | UCSY, Myanmar |
| **Mr. Sakda Sakorntanant** | PIT, Thailand | **Dr. Suvit Poomrittigul** | PIT, Thailand |

Project Duration : 1st April 2020 to 31st March 2023

Project Budget: $80,000

# Project Activities: Budget Plan (Year 2)

| Party | Purpose | Amount (USD) | Remark |
|---|---|---|---|
| UCSY | International Conference (GCCE) | 407.24 | Spent |
| UTAR | International Conference (UEMCON) | 250 | Spent |
| UTAR | International Conference (ICUFN) | 450 | Spent |
| UTAR | Journal Publication (IEEE Access) | 1850 | Pending |
| UTAR | Equipment Purchase (Wi-Fi-Extender & Uninterrupted Power Supply) | 2134 | Pending |
| | **TOTAL** | **5,091.24** | Balance of USD ~**34,000** subject to further budget planning |

# Project Activities: Group Meeting

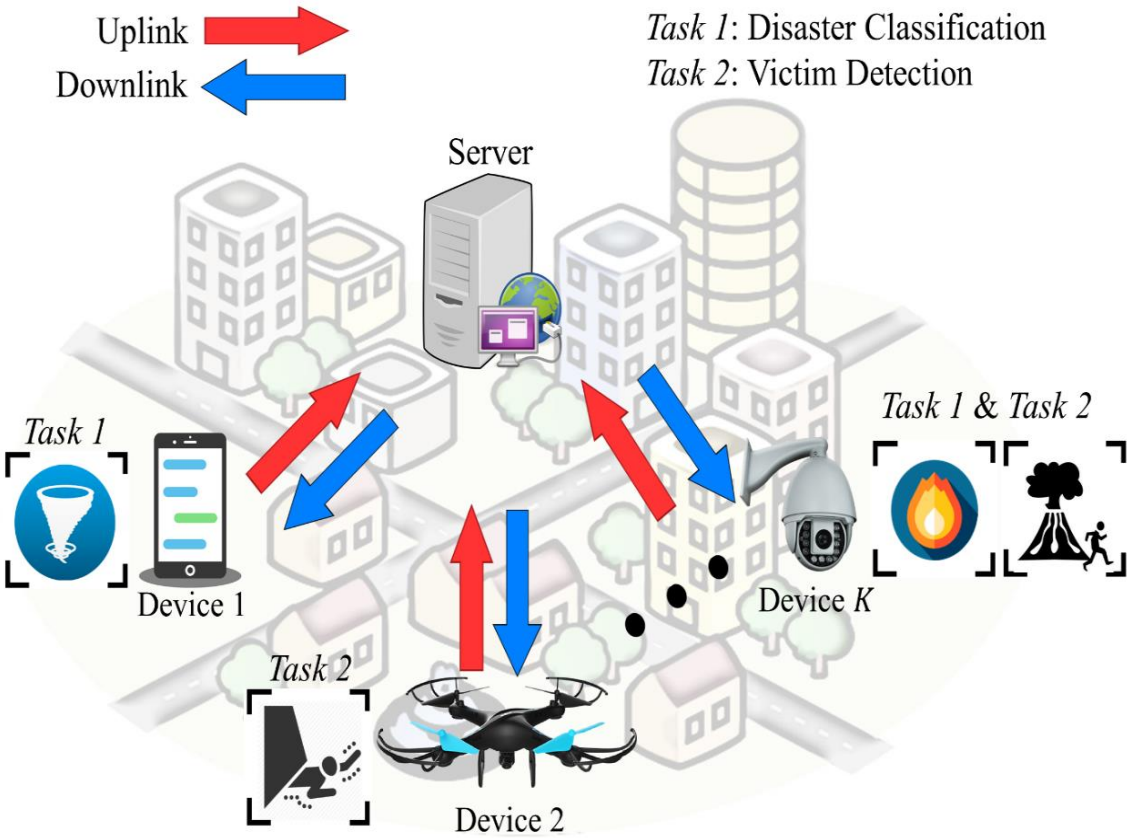
| Date | Description | Venue | Agenda |
|---|---|---|---|
| 19 Jan 2022 | 7th project meeting | WEB | • Discussion on Outcome from Project Review 2021 |
| 28 Oct 2022 | 8th project meeting | WEB | • Progress Update<br>• Discussion on Physical Meeting<br>• Adding New Members |

# Project Activities: Project Timeline (Jan – Nov 2022)

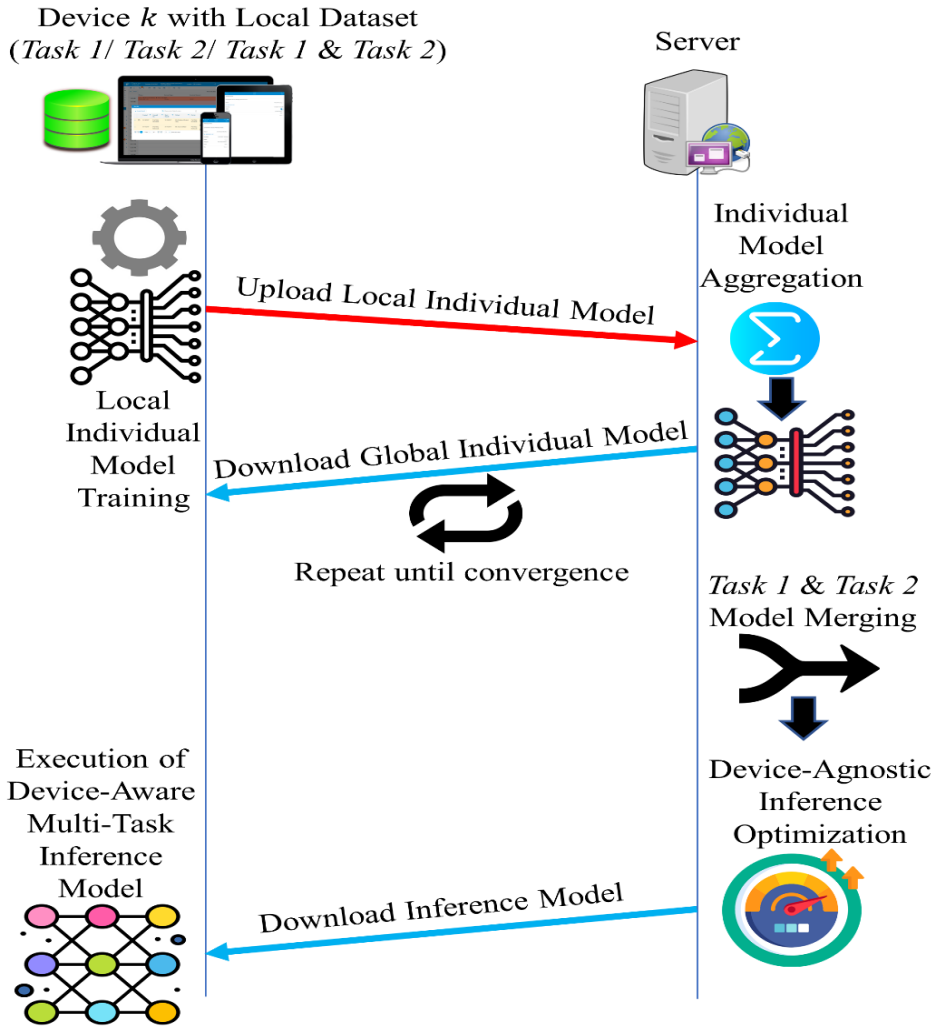
| Party | Schedule | Task Description | Remark |
|---|---|---|---|
| UTAR/NICT/BHN | Jan - Nov 2022 | • Development of Optimized Multi-Task Model for Disaster Classification and Victim Detection<br>• Deployment of IoT Nodes in UTAR Campus<br>• Large-Scale Field Testing of NerveNet Wi-Fi and NerveNet LoRA | Done |
| UTAR/MIMOS | | • Development of Efficient Device-Edge Inference for Disaster Classification<br>• Performance Evaluation of Throughput and Latency | Done |
| UCSY/UTAR | | • Development of the Route Strategy using Advanced Dijkstra Algorithm<br>• Development of Web Application for Visualization | Done |
| UTAR/PIT | | • Development of 'NerveDASH' for Disaster Monitoring Dashboard<br>• Visualization of Received Image and Text | Done |

# Project Activities (**GOAL 1**): Edge-Level Computing for Disaster Detection

## Federated Learning Environments

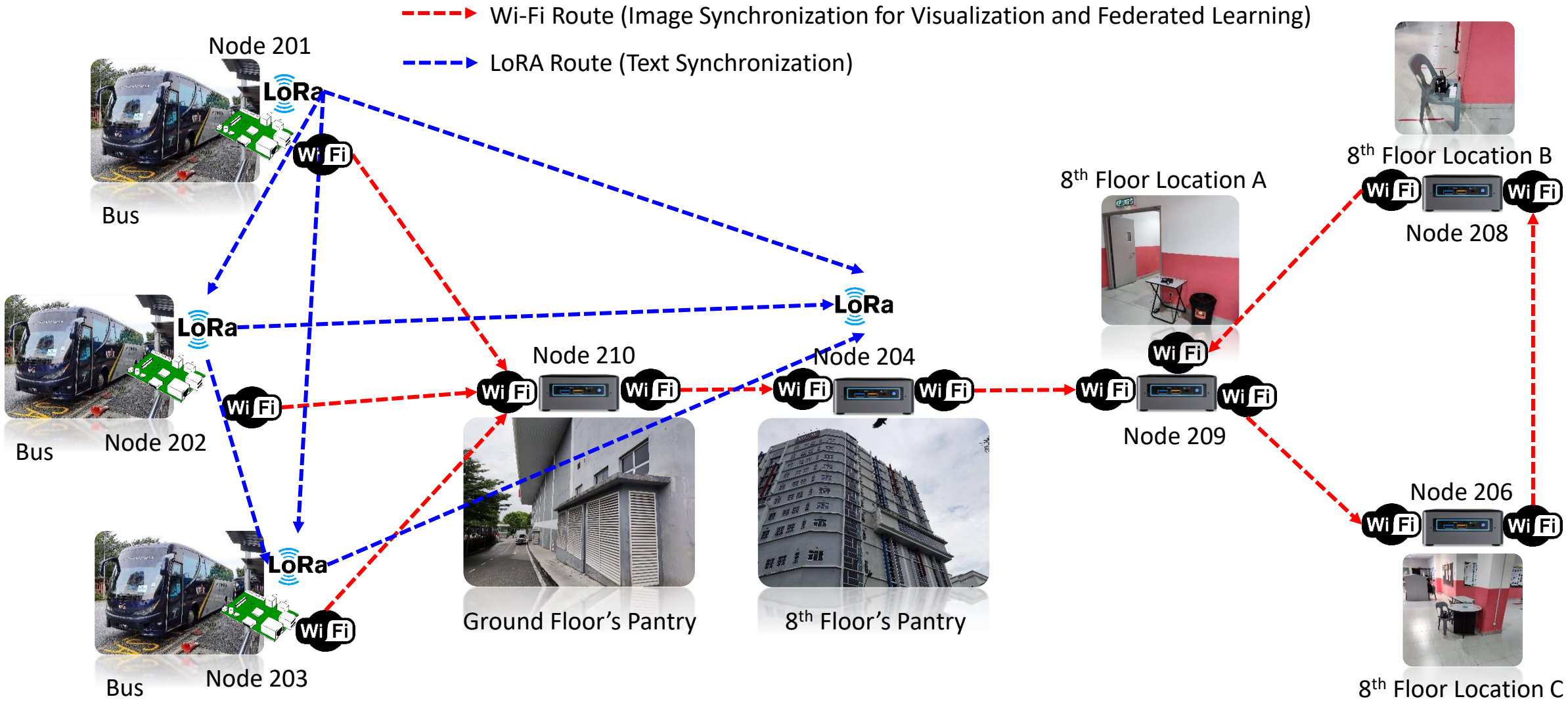



(a) Proposed Disaster Detection Framework

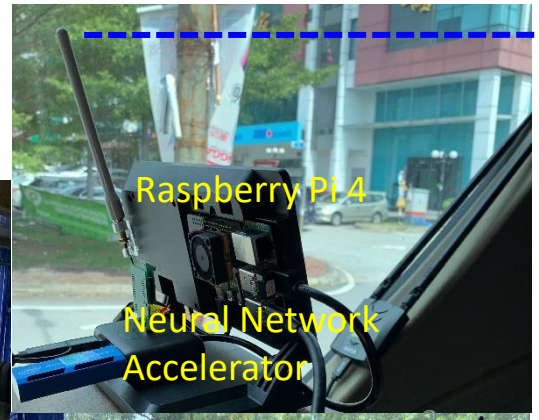



(b) Interaction from Training to Inference

# Project Activities (**GOAL 2**): WiFi-LoRa Mesh Network Testbed (Overview)



# Project Activities (**GOAL 2**): WiFi-LoRa Mesh Network Testbed (Implementation)



Bus

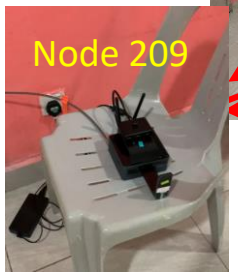
Node 210

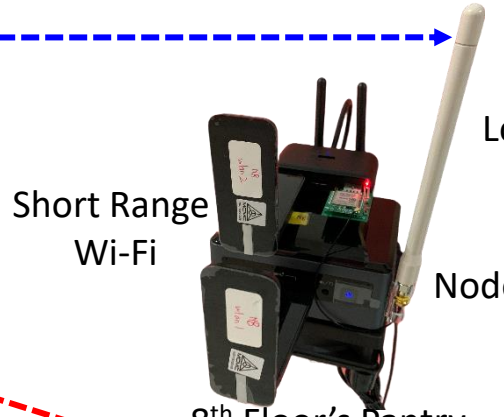
NUC



Ground Floor's Pantry


8th Floor



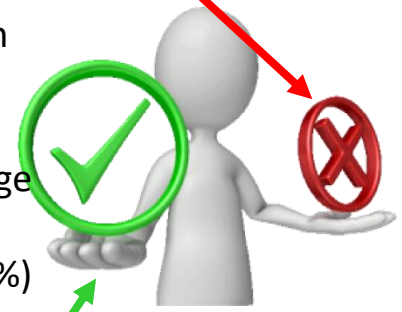

8th Floor's Pantry

# R&D results (**Goal 1**): Optimized Multi-Task Learning Model (Published in IEEE Access)

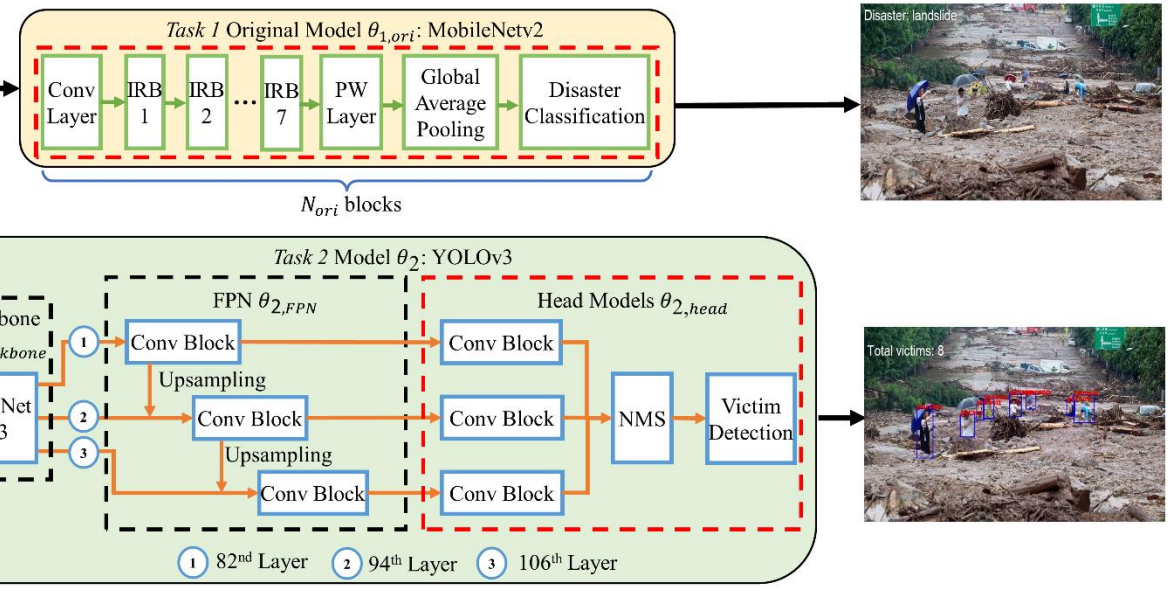
Y. J. Wong, **M.-L. Tham**, B.H. Kwan, E. M. Abraham, and Y. Owada, "An Optimized Multi-Task Learning Model for Disaster Classification and Victim Detection in Federated Learning Environments", IEEE Access, vol. 10, pp. 115930-115944, Nov 2022. 10.1109/ACCESS.2022.3218655

**Conventional Method**:
Two Separate Single-Task Models

- ✓ **LESSER** memory requirements (12.8 MB saving)
- ✓ **BETTER** disaster classification accuracy (1-2% gain)
- ✓ **SAME** victim detection performance (0.694 of average precision (AP))
- ✓ **FASTER** inference speed (18 %)
- ✓ **PORTABLE** in various hardware like CPU and Raspberry Pi



**Proposed Method**:
Multi-Task Learning Model

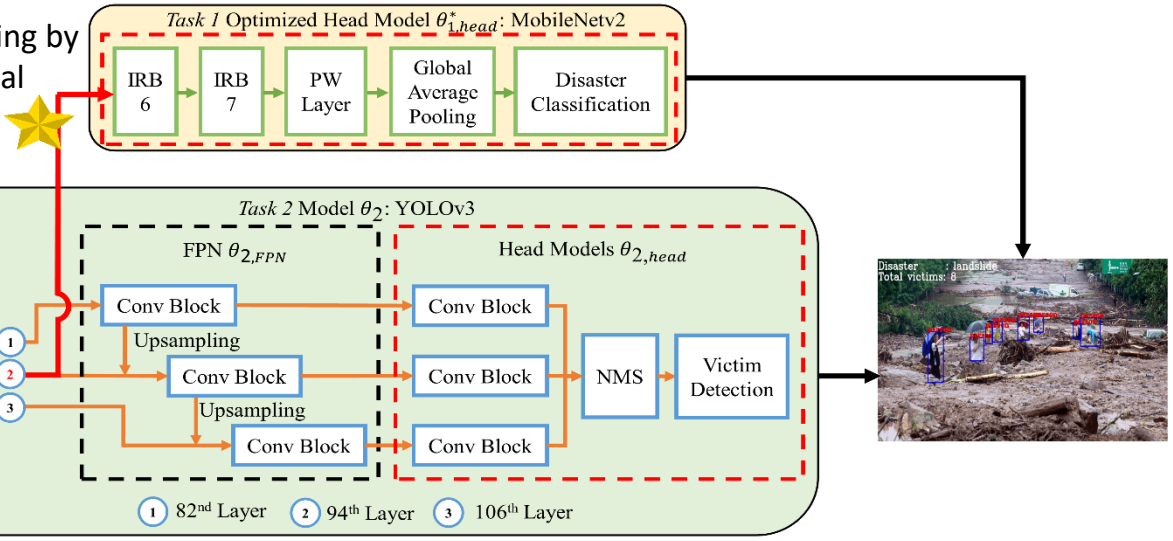






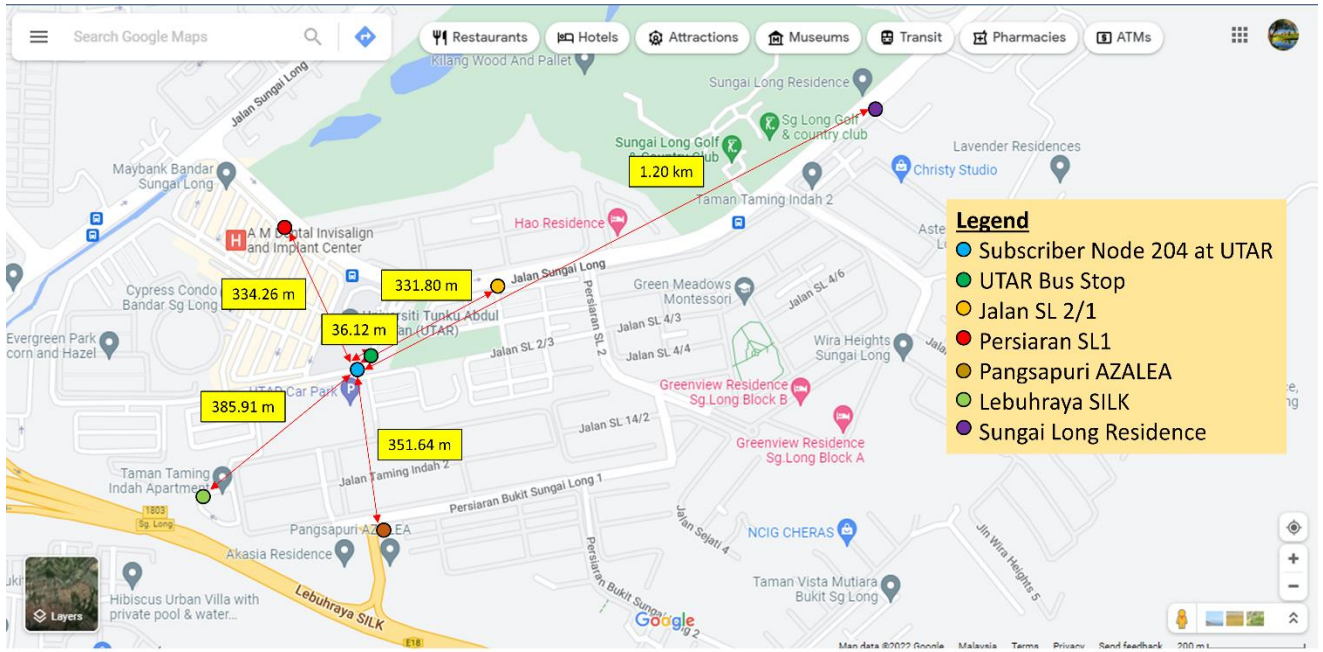


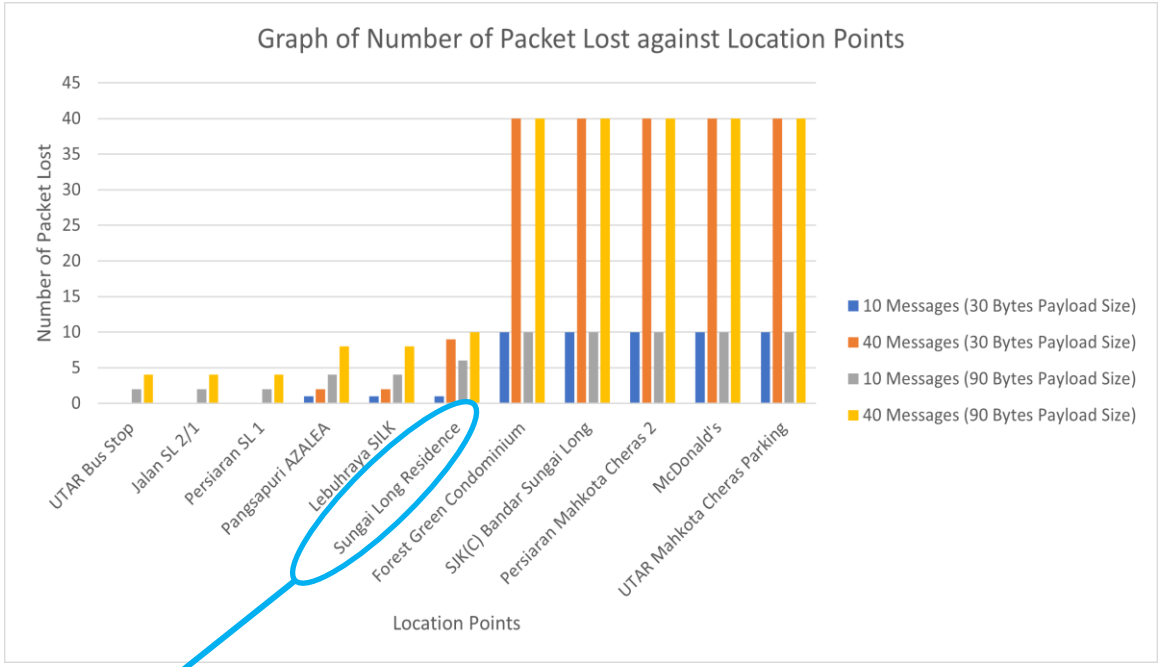

Optimal Branching by Mathematical Analysis




# R&D results (**Goal 2**): NerveNet LoRa Mesh Network

**Node 201 (Publisher) and Node 204 (Subscriber)**



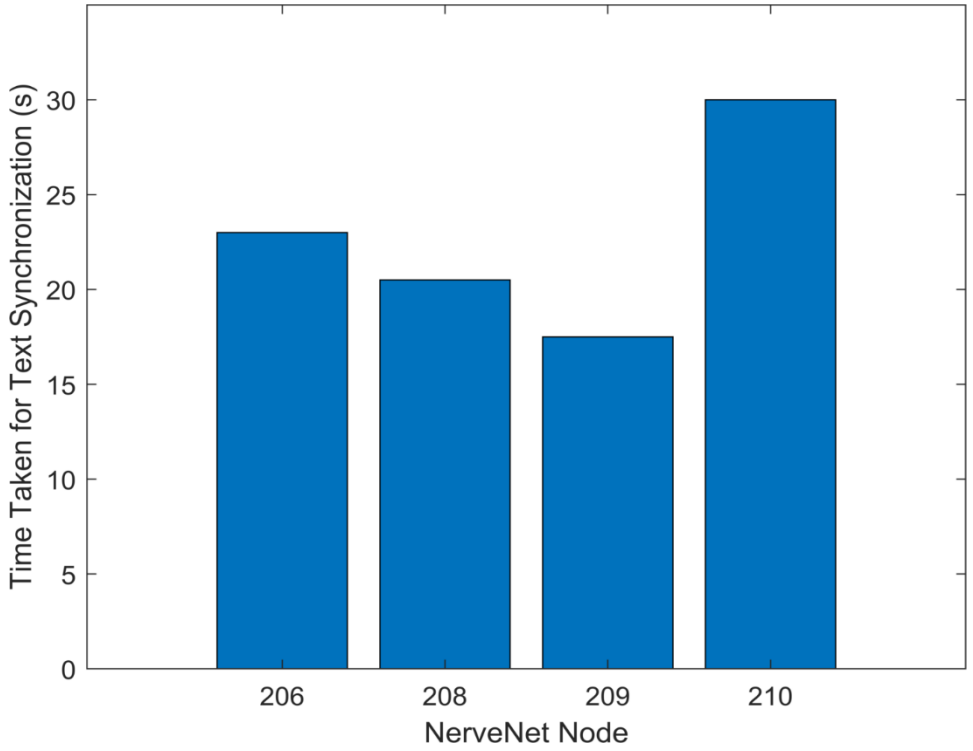





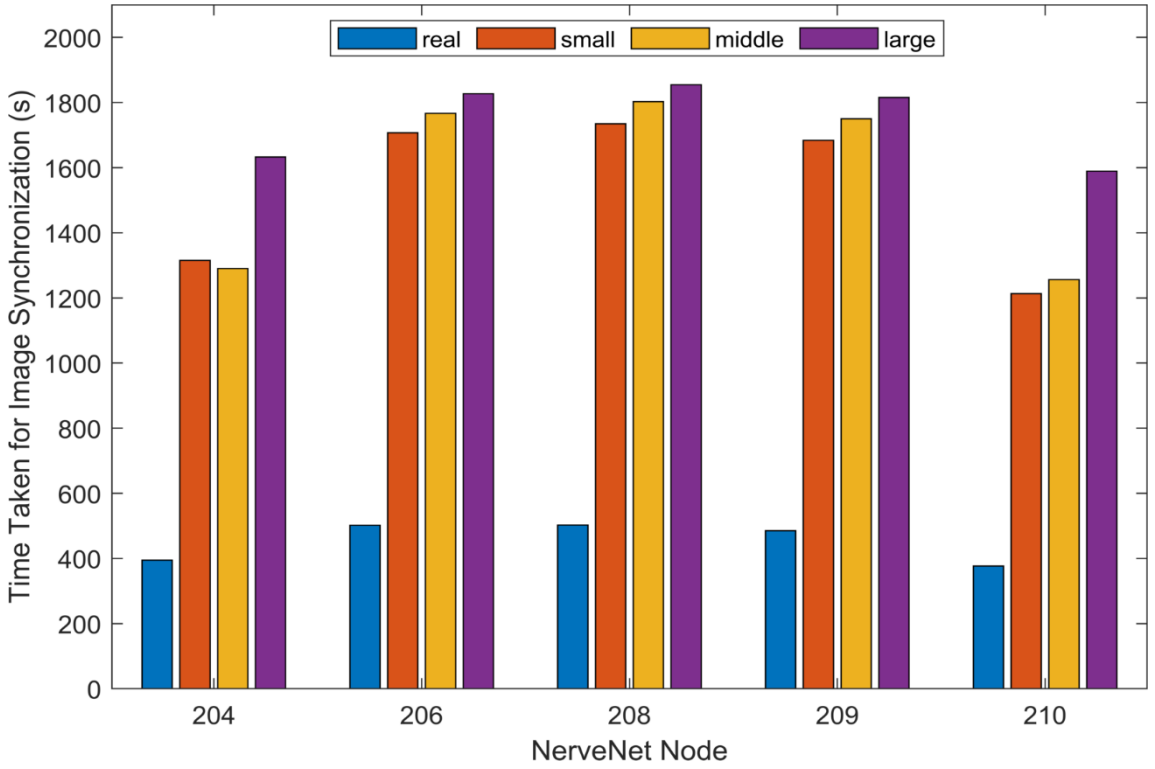
LoRa Reachable Farthest Point
(Sungai Long Residence 1.2 km)

# R&D results (**Goal 2**): NerveNet Wi-Fi Text and Image Synchronization

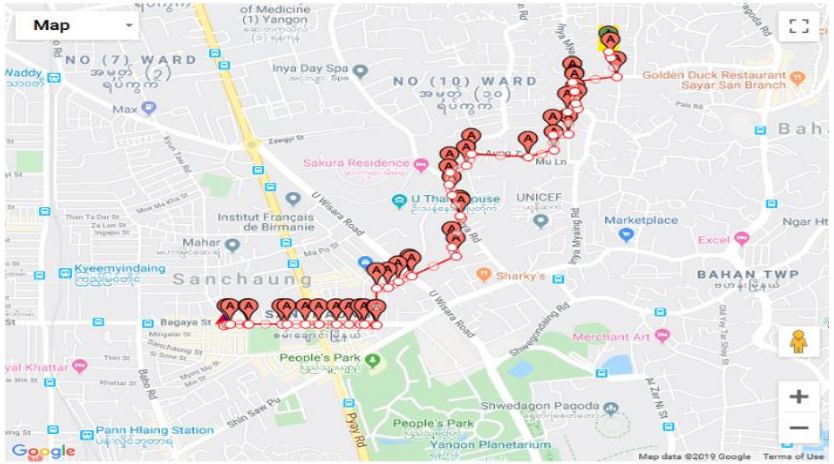
30-Byte Text Synchronization from Node 204



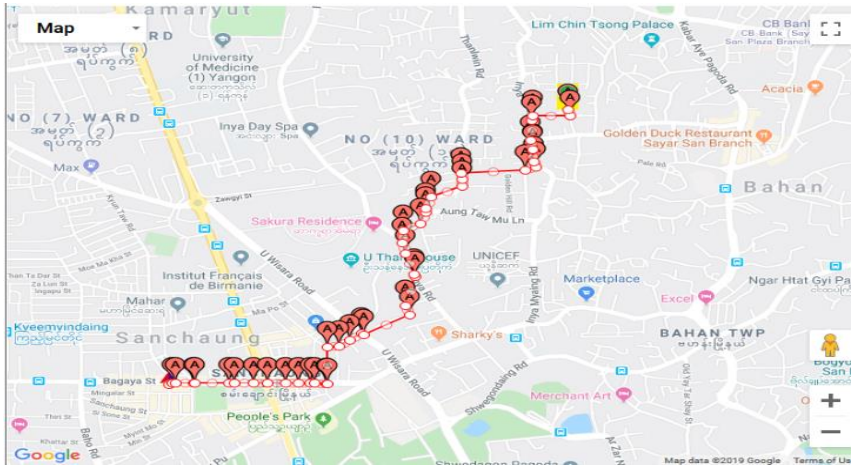

| Image File Name | File Size |
|---|---|
| real_sample.png (real) | 31.9 KB |
| image_small_size.jpg (small) | 47.4 KB |
| image_middle_size.jpg (middle) | 745 KB |
| image_large_size.jpg (large) | 1.14 MB |



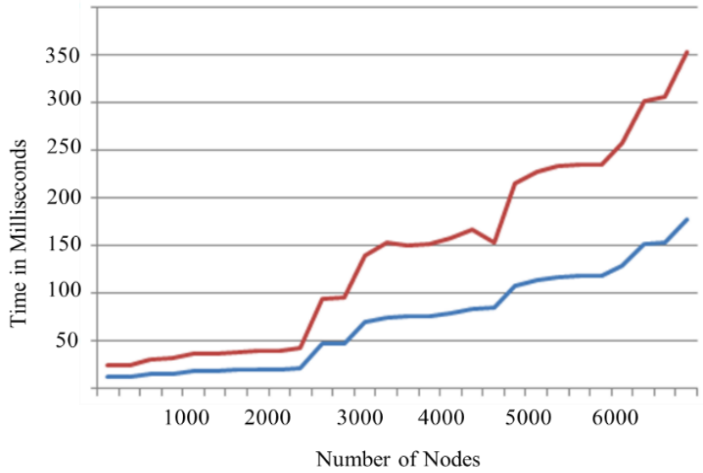
# R&D results (**Goal 3**): Evacuation Route Strategy Optimization




(a)




(b)




Proposed Method is faster.

(c)

The optimal route between the Fire Department and incident location. (a) Original modified Dijkstra's algorithm. (b) Modified Dijkstra's Algorithm (c) Runtime Complexity.

# Scientific Contribution:

Presentations at International Conferences:
Universiti Tunku Abdul Rahman (UTAR), National Institute of Information and Communications Technology (NICT), MIMOS Berhad (MIMOS), University of Computer Studies, Yangon (UCSY), Pathumwan Institute of Technology (PIT)

| No: | Paper title: | Author names | Affiliation | Conference name: | The date of the conference | The venue of the conference |
|---|---|---|---|---|---|---|
| 1. | Effective Evacuation Route Strategy for Emergency Vehicles | Myint Myint Sein[1], K-zin Phyo[1], Mau-Luen Tham[2], Yasunori Owada[3], Nordin Bin Ramli[4], Suvit Poomrittigul[5] | [1]UCSY, [2]UTAR, [3]NICT, [4]MIMOS, [5]PIT | 2021 IEEE 10th Global Conference on Consumer Electronics (GCCE) | 12-15/10/2021 | Kyoto, Japan |
| 2. | Joint Disaster Classification and Victim Detection using Multi-Task Learning | Mau-Luen Tham[1], Wong Yi Jie[1], Kwan Ban Hoe[1], Yasunori Owada[2], Myint Myint Sein[3], Yoong Choon Chang[1] | [1]UTAR, [2]NICT, [3]UCSY | 2021 IEEE 12th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON) | 01-04/12/2021 | New York, USA |
| 3. | Efficient Device-Edge Inference for Disaster Classification | Nathaniel Tan Sze Yang[1], Mau-Luen Tham[1], Sing Yee Chua[1], Ying Loong Lee[1], Yasunori Owada[2], Suvit Poomrittigul[3] | [1]UTAR, [2]NICT, [3]PIT | 2022 Thirteenth International Conference on Ubiquitous and Future Networks (ICUFN) | 05-08/07/2022 | Barcelona, Spain |

# Scientific Contribution:

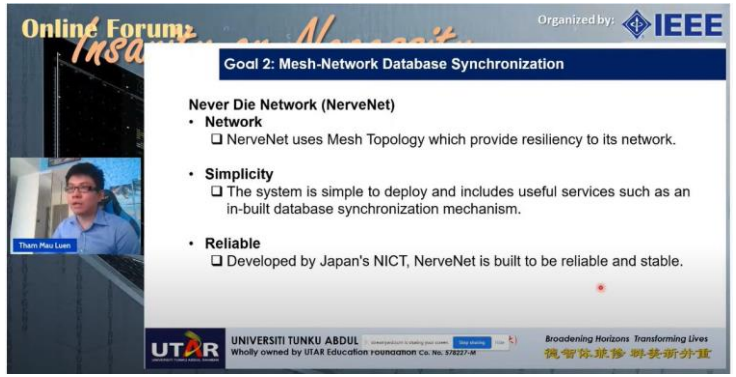
Published Journal Papers:
Universiti Tunku Abdul Rahman (UTAR), National Institute of Information and Communications Technology (NICT)

| No: | Paper title: | Author names | Affiliation | Journal name: | The publisher of the Journal | The volume number and Pages |
|---|---|---|---|---|---|---|
| 1. | An Optimized Multi-Task Learning Model for Disaster Classification and Victim Detection in Federated Learning Environments | Wong Yi Jie[1] ,Mau-Luen Tham[1*], Kwan Ban Hoe[1], Ezra Morris Abraham[1], Yasunori Owada[2] ***Corresponding Author** | [1]UTAR, [2]NICT | IEEE Access | Institute of Electrical and Electronics Engineers | Vol. 10, pp. 115930 – 115944 10.1109/ACCESS.2022.3218655 |

# Societal Impact:

**Knowledge Dissemination**: 3 international conference, 1 high impact journal of IF=3.367, 2 online forums and 1 showcase at symposium


05/08/2021
52nd Asia Pacific Advanced Network (APAN)




21/10/2021
IEEE Malaysia ComSoc/VTS Joint Chapter


13/10/2022
The 3rd Symposium on Railway Infrastructure & Engineering (SRIE 2022)

# Conclusion:

**Goal 1:**

- A multi-task learning (MTL) model that performs joint disaster classification and victim detection has been developed.
- As compared to the conventional approach, the proposed model has lesser memory requirements and better classification-related results, while preserving the same detection-related performance.
- The first advantage would be very useful in IoT environment, where the data (e.g., network weights) are exchanged.

**Goal 2:**

- The NerveNet Wi-Fi has been deployed to enable image synchronization.
- The NerveNet LoRa has been deployed to enable text synchronization.
- To allow nationwide monitoring and control, NerveDASH has been developed to visualize data collected from multiple regional mesh networks.

**Goal 3:**

- The estimation of effective emergency route strategy has been proposed for complexed road network of Yangon.
- The proposed work will help emergency rescue teams to reach the incident location in a short time save the lives and properties.

# Future works:

| Party | Schedule | Task Description |
|---|---|---|
| UTAR/NICT/BHN/MIMOS/UCSY/PIT | 12-14 Dec 2022 | • Project Closing Meeting at UTAR, Malaysia |
| UTAR/NICT/BHN/MIMOS/UCSY/PIT | Jan - March 2023 | • More field testing of NerveNet Wi-Fi and NerveNet LoRA<br>• Installation of Uninterrupted Power Supply in UTAR Bus<br>• Documentation and Journal / Conference Paper Submission |