Final Project Report
Detailed Form

I. Title of Proposed Project:

ASEAN forum for Software Defined System on Disaster Mitigation and Smart Cities

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IV. Project Report

i) Introduction

This project addresses the impact of climate change on cities and urbanization, with particular relevance to the priority area of improving environmental resilience and more specifically in disaster mitigation. This collaboration proposes a flexible and robust distributed framework for disaster mitigation, crisis communication and emergency management that can monitor disaster events in near-realtime, based on computational platforms, ranging from automated weather sensors, water gauges, smartphones and laptops, to remote computing and data storage platforms. – the platform would be based on dual-use infrastructure using the latest Software Defined System technologies. The proposed forum will find critical technologies, use cases and develop and deploy collaborative platform in ASEAN region. Use of NICT's existing testbeds such as JGN-X, Starbed and JOSE will have great leverage of research and development. Collaborating with already funded activities in each institution as well as outside projects such as PRAGMA (NSF, US), CENTRA (NSF, US) and CECEA (Taiwan), we can accelerate our activities.

ii) Project Activities

(1) Development and Implement

In order to better explore various ideas that may be suitable for the blueprint, 5 project meetings were held between 2016 and 2018 to allow members to discuss these ideas and coordinate the activities or experiments among them. Project members generally utilizes off-the-shelf and open source technologies and solutions in all activities.

The project activities are divided into 3 sub-projects focus on 3 different themes,

they are:

a) Visualization of Distributed Environmental Data
Technologies explored: OpenVSwitch, Ceph, SAGE2, OpenStack

Activity 1: A wide area network software defined storage was setup using JOSE cloud resources from different data centers over JGN-X and using SDN concept via PRAGMA-ENT, a virtual client in MIMOS (Malaysia) access sensor data from internet and then stored the data into this storage using NFS.

Conclusion 1: The testbed behaved as per expectation, challenges in bandwidth and latency are still a concern. Moving forward to design a WAN base storage that encompass ASEAN region and with different data format and sizes as well as exploring data management and analytics in Edge Computing (for example exploring AI platform on-premise or edge as published by MIMOS) [IV.iii)(1)a)].

Activity 2: Developing sample code for distributed collaborative visualization using SAGE2. Local SAGE2 environment was setup and tested in MIMOS. AIST team provided a sample code that can be later use to port an existing simple web-based sensor data dashboard (as shown below) to SAGE2 with GIS information added.

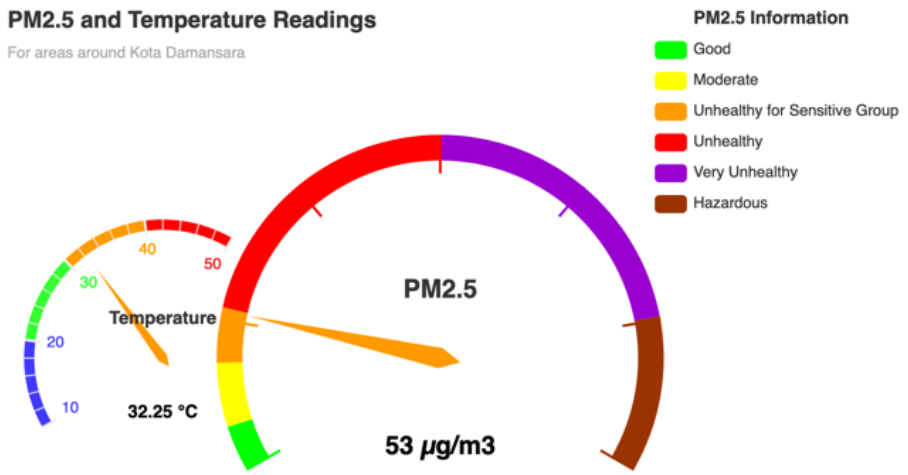

Diagram 1: A Simple Web based dashboard for Air Quality Sensor (source: MIMOS)

Conclusion 2: SAGE2 is a viable platform to share dashboard for different sites such as smart cities' command and control centers. Challenges are in getting the necessary data and developing the applications that reflect those data [IV.iii)(4)b), V.ii), V.iii), V.iv), V.v)].

b) SDN-IP Peering for IoT Data Transmission
Technologies explored: OpenVPN, Quagga, ONOS

Activity: This particular activity focuses on experimenting various SDN-IP peering configurations on the said testbed and documenting various challenges of deploying a combination of software-based routing and hardware base systems.

Conclusion: SDN-IP Peering is a viable way to create a software defined network backbone. Current challenges mainly revolve around implementations using both software based and hardware-

based solutions as well as documentations on how these challenges can be resolved. Initial documentation was released in second half of 2018 led by researchers from NCHC [V.i].

c) SDN/NFV Infrastructure
Technologies explored: OpenDayLight, MQTT, Mininet
Activity: This activity aims to getting all members to familiarize with SDN and NFV technologies. Major effort is devoted to knowledge sharing and training so that all members are capable of building their own local SDN/NFV testbed and value add to the existing tools (for example as published by MAPUA on data transmission between Philippines and Vietnam using OpenDayLight and Mininet [IV.iii)(1)d)]). Members in this team are also researching and developing different methods and applications for smart cities (as demoed by VNU during CENTRA3 a simple SDN/NFV concept for street light controller) as well as disaster management (for example emergency vehicle routing published by UCSY [IV.iii)(1)g)])

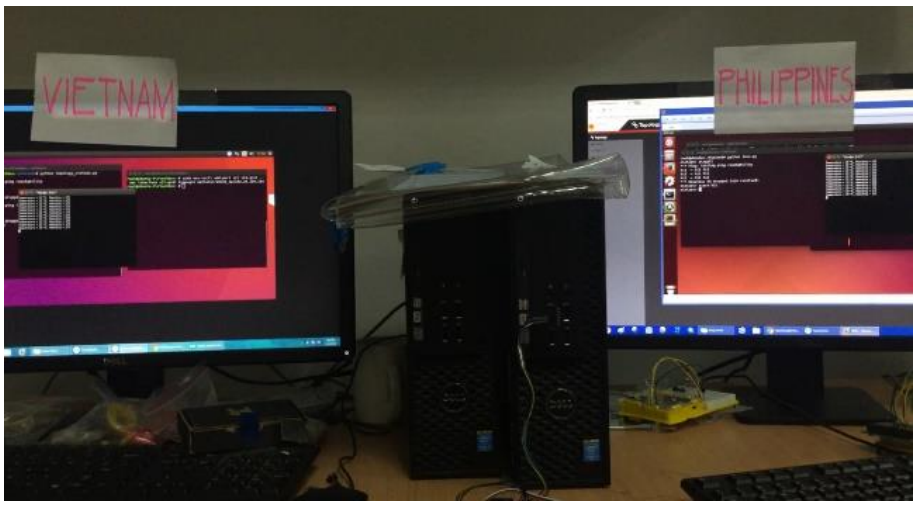

Diagram 2: Experimental Setup for Data Transmission between MAPUA and VNU (source and acknowledgement: MAPUA University)

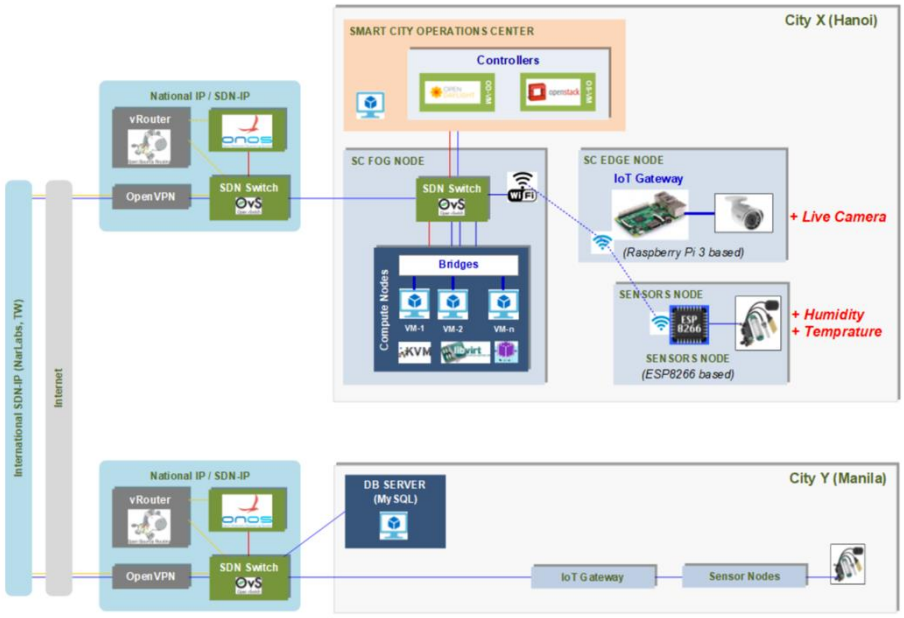

Diagram 3: Experimental Testbed Setup (source and acknowledgement: VNU)

(2) Leveraged Resources and Participants

All project members used and contributed their own resources during this project period. Members use existing resources from their institutes for the project activities, **no additional hardware/equipment were acquired using project funding**. Based on the sub-projects:

a) Visualization of Distributed Environmental Data
   a. Members: MIMOS, AIST, ASTI, NICT, NECTEC, NAIST (project partner)
   b. Resources: NICT (JGN-X/JOSE), NAIST (PRAGMA-ENT), MIMOS (Server, Ceph Storage), NECTEC (Ceph storage), ASTI (sample data), AIST (SAGE2 sample code)

b) SDN-IP Peering for IoT Data Transmission
   a. Members: NICT, NECTEC, ASTI, HUST, NCHC (project partner)
   b. Resources: All participating members used their own server and switch during the experiment

c) SDN/NFV Infrastructure
   a. Members: VNU, UCSY, HUST, MAPUA
   b. Resources: VNU (IoT devices and demo apps), MAPUA (sensors and apps), UCSY (apps on disaster management)

(3) Findings and Outcomes

Initial studies indicate that Software Defined Systems can provide potential solutions to setup a resilient infrastructure to support activities in smart cities and disaster management [IV.iii)(2)a)].

As published by MAPUA University, SDN can provide a reliable connectivity for data transmission over 2 countries [IV.iii)(1)d)]. With a maturing SDN-IP Peering in progress, it is possible in a foreseeable future that a regional SDN based network infrastructure can provide the necessary resilient infrastructure to support activities for smart cities and disaster management. For example, by

using the underlying SDN and coupled with a WAN base Software Defined Storage, critical data such as weather and climate as well as other information for the ASEAN region can be reliably stored and shared in the event if natural disaster disrupts one country's infrastructure.

An important outcome of such resilient infrastructure will be fully explored when more applications such as those researched and developed for route assessment for emergency vehicles, bridge monitoring in smart cities, air quality data and so on can be monitored collaboratively and shared among cities and even countries in ASEAN.

A proposed blueprint for such activities is illustrated in the following diagram:

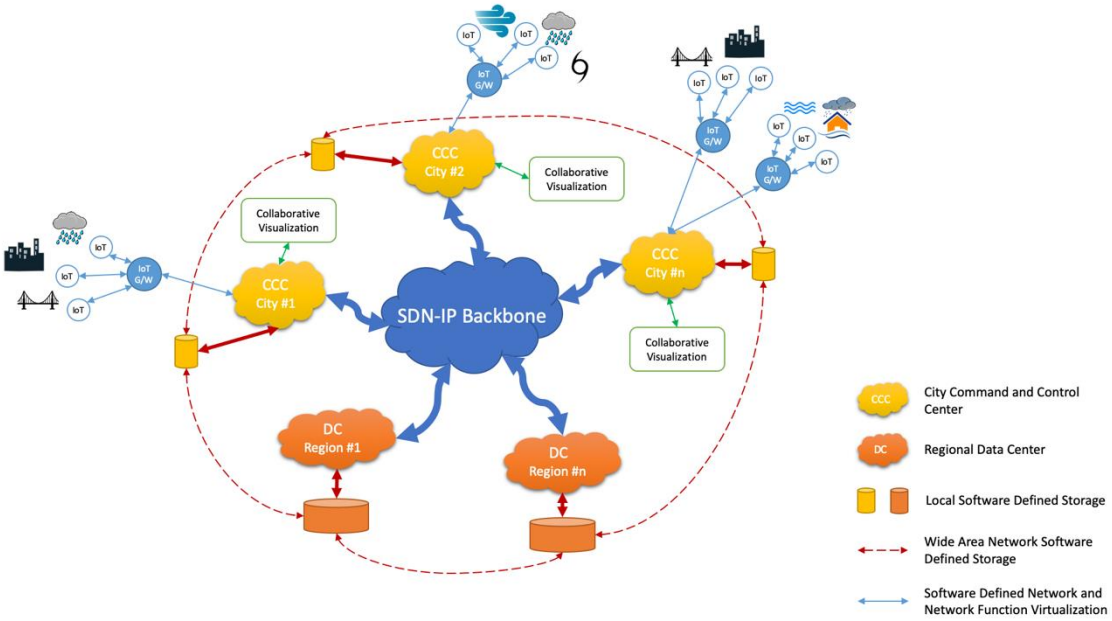

Diagram 4: Proposed Blueprint for Software Defined System for Smart Cities and Disaster Management

In the proposed blueprint, SDN-IP will be used as the backbone to serve smart city/disaster management ecosystem that may consist of various command and control centers as well as data centers. Each center hosts its own software defined storage where data are replicated across a wide area network software defined storage for redundancy. Access from the center to various IoT devices (sensors, actuators, etc.) are via a combination of software defined network and network function virtualization.

(4) Broader Impact

By using the programmable capabilities of the underlying network infrastructure, i.e., SDN/NFV and Distributed Object Storage technologies, we can foresee that during an outage due certain disaster, different centers from different cities can share the load as the data can still be collected and shared with redundancy from the wide area software defined storage and that monitoring/planning/decision

making/etc. can be made using the collaborative visualization.

(5) Future Developments

Further developments can be considered in the following areas:

a) Intelligent Dynamic Routing in SDN-IP Backbone
b) IoT Security
c) Network Function Virtualization for IoT
d) Intelligent Secure Edge Computing Deployment for IoT
e) Applications for emergency management and disaster management
f) Edge Computing and Edge Analytics
g) Actual field work, proof-of-concept, implementing the proposed blueprint

iii) Social Contribution

(1) Publications

a) Ismail, Bukhary Ikhwan, et al. "Implementing an On-Premise AI Platform: From DC to Edge", 10th International Conference on Networking and Information Technology, ICNIT, 2019 (MIMOS)
b) Khalid, Mohammad Fairus, et al. "Super-Convergence of Autonomous Things", The 10th International Conference on ICT Convergence (ICCSCE). IEEE, 2019
c) "Comparison of Traditional Network and Software-Defined Network using GNS3 and Mininet", 2018 ICpEP National Convention, 6th National Conference on Computer Applications, Innovations, Technologies and Engineering (CAITE 2018) (MAPUA)
d) Bonifacio, A.C.P., Galo, P.J.C., Lopena, J.M.D., Villaverde, J.F., Magwili, G.V. "Resilient network and data transmission between Philippines and Vietnam via software-defined network using OpenDayLight controller and Mininet", 2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management, HNICEM 2018. (MAPUA)
e) K-zin Phyo and Myint Myint Sein, "Effective Evacuation Route System During Natural Disaster", Asia Pacific Advanced Network Research Workshop (APAN 44), Dalian, China, August 26 – September 1, 2017, pp.70-75. (UCSY)
f) K-zin Phyo and Myint Myint Sein, "Investigation of Optimum Rescue Itinerary by Using Advanced Routing Method", IEEE 7th Global Conference on Consumer Electronics, Nara, Japan, October 4-13, 2018, pp.521-522. (UCSY)
g) "Optimal Route Assessment for Emergency Vehicles Travelling on Complex Road Network", 11th Multi-disciplinary International Workshop on Artificial Intelligence, 2017 (UCSY)
h) "Effective Emergency Response System by Using Improved Dijkstra's Algorithm", 14th International Conference on Computer Applications, ICCA, 2017
i) "Optimal Route Finding for Weak Infrastructure Road Network", Genetic and Evolutionary Computing Proceedings of the Tenth International Conference on Genetic and Evolutionary Computing, 2017 (UCSY)
j) "Quantitative Risk Assessment of Container Based Cloud Platform", AINS 2017 (MIMOS)
k) "CLOF: A proposed Containerized Log management Orchestration Framework", ICOS 2017 (MIMOS)
l) "Reference Architecture for Search Infrastructure", ICCSCE 2017 (MIMOS)
m) "Extending Cloud Resources to the Edge: Possible Scenarios, Challenges and

Experiments", ICCCRI, 2016 (MIMOS)
n) "Ext4, XFS, BtrFS and ZFS Linux File Systems on RADOS Block Devices (RBD): I/O Performance, Flexibility and Ease of Use Comparisons", ICOS 2016 (MIMOS)
o) BI Ismail, MF Khalid, OH Hoe, "Policy Management for Docker Ecosystem Managing Edge Computing Devices", The 20th International Computer Science and Engineering Conference 2016 (MIMOS)

(2) Presentations

a) "SDN, IoT and Fog Computing testbed for Smart Cities", SEAIP 2018 (VNU)
b) "ASEAN Forum for Software Defined System for Disaster Mitigation and Smart Cities: An ASEAN IVO Project", CENTRA 3, 2018 (MIMOS)
c) "ASEAN Forum for Software Defined System for Disaster Mitigation and Smart Cities", CENTRA 2/PRAGMA 32, 2017 (MIMOS)
d) "ASEAN Forum for Software Defined System for Disaster Mitigation and Smart Cities: An ASEAN IVO Project", SEAIP 2017 (MIMOS)
e) "eResearch Australasia BoF on Transnational Collaborative Research on Smart and Connected Communities", BoF session eResearch Australasia, 2017 (NICT)
f) "ASEAN IVO Project: Software Defined System on Disaster Mitigation and Smart Cities", APAN 42 Future Internet Testbed Working Group, 2016 (AIST)
g) "Visualization of Distributed Environmental Data", CENTRA Webminar, SEAIP 2016 (MIMOS)

(3) Patents

None

(4) Demos

a) IoT/NFV/SDN, CENTRA 3, Tokyo, 2018, (VNU)
b) "Bridging Talents through SAGE2 Collaboration over SDN/IP", SC18, SCinet Network Research Exhibition, USA, 2018 (https://sc18.supercomputing.org/app/uploads/2018/11/SC18-NRE-012.pdf)

V. Other References

i) SDN-IP Installation and Configuration (https://docs.google.com/document/d/14Dg0j9KNAyzTa-WYyubDfr8zUOFq4yyZ8CiCfQMt1jg/edit?usp=sharing)
ii) AirBox status report (https://pm25.lass-net.org/AirBox/)
iii) PM2.5 Open Data (https://sites.google.com/site/pm25opendata/open-data)
iv) "SAGE2: A New Approach for Data Intensive Collaboration Using Scalable Resolution Shared Displays", 10th IEEE International Conference on Collaborative Computing: Networking, Applications and Worksharing, 2014
v) "An Interactive Platform for DLaaS on SAGE2- Traffic Monitoring as an Example", PRAGMA 34, 2018, Japan (https://github.com/pragmagrid/pragma-meetings/blob/master/pragma34/11/demo-3.pdf)