Software Defined MICRONet

Mobile **I**nfrastructure for **C**oastal **R**egion **O**ffshore Communications & **Net**works

Amal Krishna R

Project Advisor: Dr. B. S. Manoj

Indian Institute of Space Science and Technology
Thiruvananthapuram, Kerala, India 695547

May 5, 2016

Outline

Motivation

- Small scale fishing is one of the major source of livelihood across thousands of villages in India
- Employs over 14 million people in India
- Need for an intelligent, reliable, and low-cost communication technology solutions

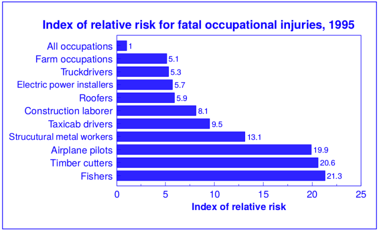

Figure 1 : Index of Relative risk[1]

[1] The index of relative risk. *http://www.bls.gov.* accessed: 1-2-2016.

Objectives

1. Develop an Intelligent and affordable communication system for fishermen
2. Define a suitable metric for controller selection in software-defined environments
3. Develop a prototype testbed and analyze the performance of Software Defined MICRONet architecture

Introduction

- Existing communication: legacy VHF radios in broadcast mode with line-of-sight coverage
- Coverage is limited to about 15 km from shore
- A low-cost communication infrastructure
- Multi-level Point-to-Multi-Point architecture based on Long Range WiFi

MICRONet architecture

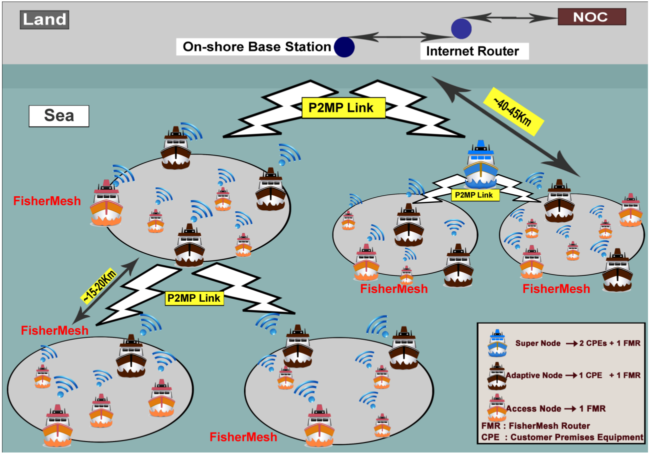

Figure 2 : MICRONet Architecture[2]

[2] Nandesh Nair Jennath Hassan Sethuraman N Rao. "A Resilient Self-Organizing Offshore Communication Network for Fishermen". In: (2015).

MICRONet hierarchical view

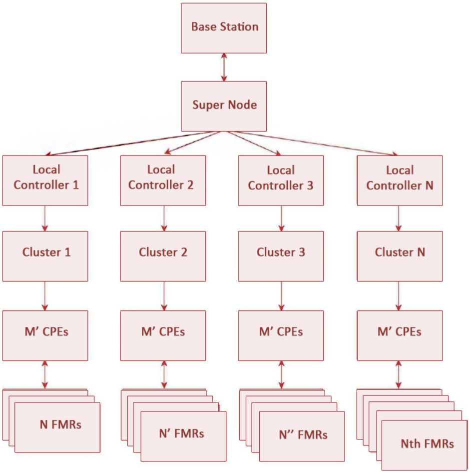

Figure 3 : Hierarchical view[3]

[3] Nandesh Nair Jennath Hassan Sethuraman N Rao. "A Resilient Self-Organizing Offshore Communication Network for Fishermen". In: (2015).

Software Defined Networking (SDN)

1. Novel approach to computer networking
2. Two important planes in a computer network
   - Data plane
   - Control plane
3. Data plane handles forwarding of user traffic
4. Control plane supports data plane with
   - Decision making
   - Creation of routing tables
5. Decoupling control plane and data plane
6. In traditional networks both these planes reside inside a switch

Literature survey

- MICRONet architecture[4]
- Master controller selection in multiple controller scenarios[5]
- A dynamic multihop handoff solution based on RTT/ETX for OpenFlow WMNs[6]
    - ETX is considered to be a stable metric for controller handoffs

[4] Nandesh Nair Jennath Hassan Sethuraman N Rao. "A Resilient Self-Organizing Offshore Communication Network for Fishermen". In: (2015).

[5] Stefano Salsano et al. "Controller selection in a Wireless Mesh SDN under network partitioning and merging scenarios". In: *arXiv preprint arXiv:1406.2470* (2014).

[6] Aditya Vamsi Mamidi, Sarath Babu, and BS Manoj. "Dynamic multi-hop switch handoffs in Software Defined Wireless Mesh Networks". In: *2015 IEEE International Conference on Advanced Networks and Telecommuncations Systems (ANTS)*. IEEE. 2015, pp. 1–6.

Contoller selection metrics: RTT vs. ETX

Expected Transmission Count (ETX)

The number of transmissions required to successfully deliver a packet over a wireless link

$$ETX = \frac{1}{Df \times Dr}$$

Round Trip Time (RTT)

Time required for a message to travel toward the destination and return back to the source

- A dynamic multihop handoff solution for OpenFlow WMNs
- Compared to RTT, ETX is observed to be a stable metric

ETT as decision metric

Expected Transmission Time (ETT)

Time to successfully transmit a packet towards the destination

- It is an extension of ETX which takes into account packet size and link bandwidth.

$$ETT = ETX \times \frac{S}{B}$$

- S denotes the average size of packet and B denotes current link bandwidth
- It can increase the throughput of path by measuring the link capacities and would increase the overall performance of the network.
- Metrics unaware of link quality cannot guarantee resonable stability and accpetable loss rates
- ETT reflects various physical-layer characteristics, such as loss probablity and transmission rate

Our Work

Software Defined MICRONet Architecture

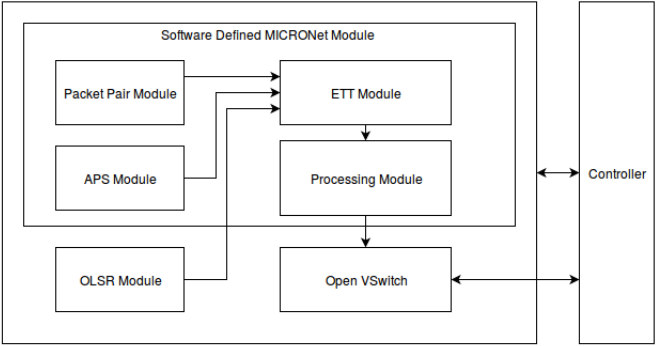

Figure 4 : Software Defined MICRONet Architecture

Software Defined MICRONet architecture

- **Packet Pair Module**: computes the link bandwidth using the packet pair method
  - probe packets of 1137 bytes and 137 bytes

$$B = 8 \times \frac{Lp}{Tp}$$

  - Lp denotes Size of larger probe packet and Tp denotes time difference of arrival of probe packets
- **APS Module**: calculates the Average Packet Size using tcpdump
- **ETT Module**: with the data obtained from Pack Pair module and APS module, it computes the ETT for each link
- **Processing Module**: with the calculated ETT value the Software defined MICRONet module adapts to the possible scenarios that arise in such an environment

Scenario 1

- Physical cluster with no back-haul links

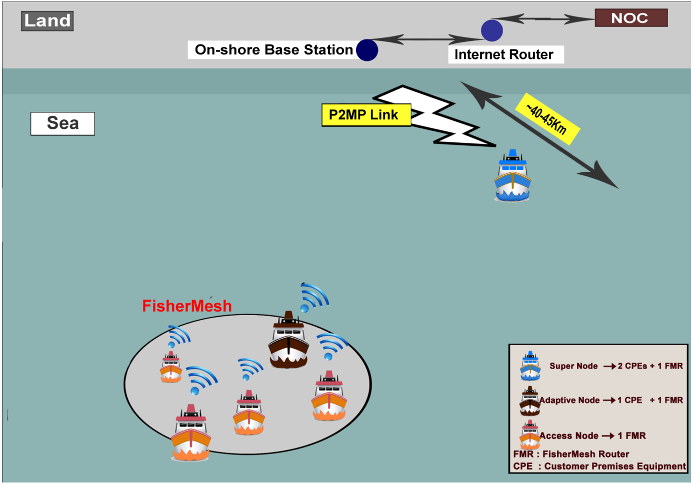

Figure 5 : Scenario 1

Proposed solution

```
start olsrdm;
while back-haul links = 0 do
    determine the ANs;
    if number of AN != 1 then
        master-election();
        master = ANi slave = ANj start controller in ANi and ANj;
        invoke set-controller command in rest of the FMRs;
        start open-vswitch in rest of the FMRs;
    else
        master = AN;
        start controller in master;
        invoke set-controller command in rest of the FMRs;
        start open-vswitch in rest of the FMRs;
    end
end
```

Algorithm 1: No back-haul links

Scenario 2

- Physical cluster network with 2 back-haul links.

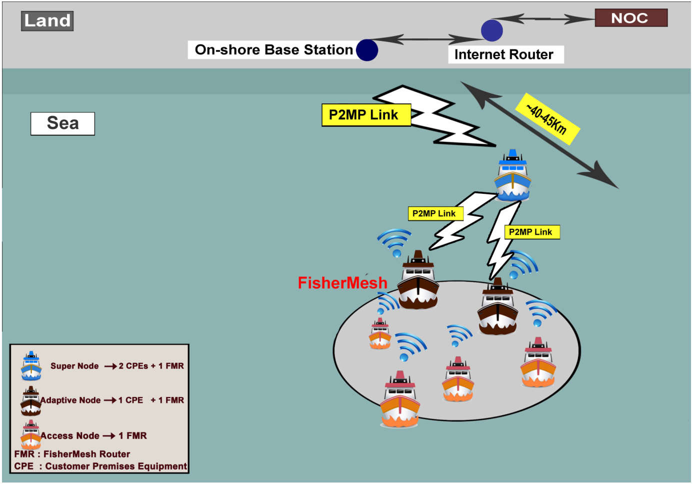

Figure 6 : Scenario 2

Proposed solution

```
start olsrdm;
while back-haul links = 2 do
    adaptive-node-list();
    compute ETT to both access node;
    if ETT-AN1 < ETT-AN2 then
        master = AN1;
        slave = AN2;
    else
        master = AN1;
        slave = AN2;
    end
    start controller in master;
    invoke set-controller command in rest of the FMRs;
    start open-vswitch in rest of the FMRs;
end
```

Algorithm 2: 2 back-haul links

Scenario 3

- Multilayer hierarchical physical cluster with 1 back-haul link.

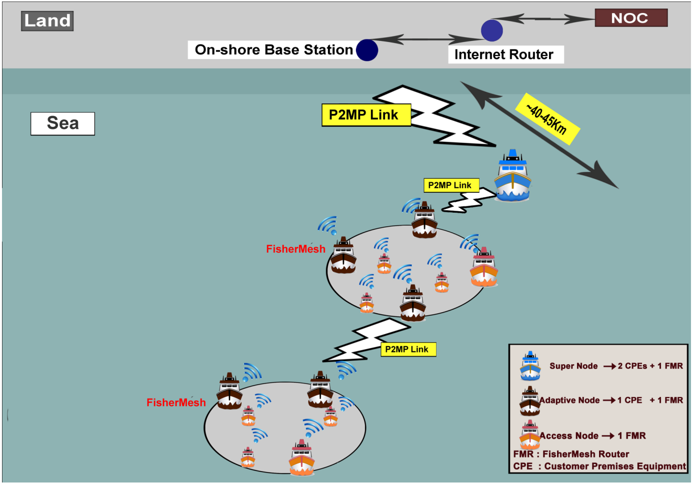

Figure 7 : Scenario 3

Proposed solution

```
start olsrdm;
while AN and back-haul links = 1 do
    adaptive-node-list();
    determine forward back-haul AN;
    determine backward back-haul AN;
    if backward back-haul link then
        master = AN;
        start controller in master;
    else
        pass;
    end
    invoke set-controller command in rest of the FMRs;
    start open-vswitch in rest of the FMRs;
end
```

Algorithm 3: Hirearchical sub cluster with back-haul link

Major contribution

1. Developed a Software Defined MICRONet architecture
2. Developed a test-bed for Software Defined MICRONet
3. Analyzed the performance of ETT-based controller selection

Performance analysis and results

Alix.3d3 specifications

ALIX.3d3 features

PC Engines ALIX boards are small form factor system boards optimized for wireless routing and network security applications.

- AMD Geode LX CPU, 500 MHz (LX800) 5x86 CPU
- 256 KB cache (64K data + 64K instruction + 128K L2)
- 1 Ethernet channel (Via VT6105M, 10 / 100 Mbit/s)
- 2 miniPCI sockets for 802.11 wireless cards and other expansion
- 256 MB DDR SDRAM, 64 bit wide for high memory bandwidth
- 512 KB flash with Award BIOS
- CompactFlash socket for user's operating system and application
- 7 to 20V (absolute maximum, recommend 18V) DC supply through DC jack or passive power over Ethernet. Suggest a 18V / 15W supply. Center pin = positive, sleeve = ground, 2.1 mm diameter.
- 1 serial port (DB9 male)
- 2 USB 2.0 ports
- Header for LPC bus (use for flash recovery or I/O expansion)
- Temperature range 0 to 50°C
- Dimensions 100 x 160 mm

Figure 8 : Alix.3d3 Specifications

Two node ETT experiment (1)

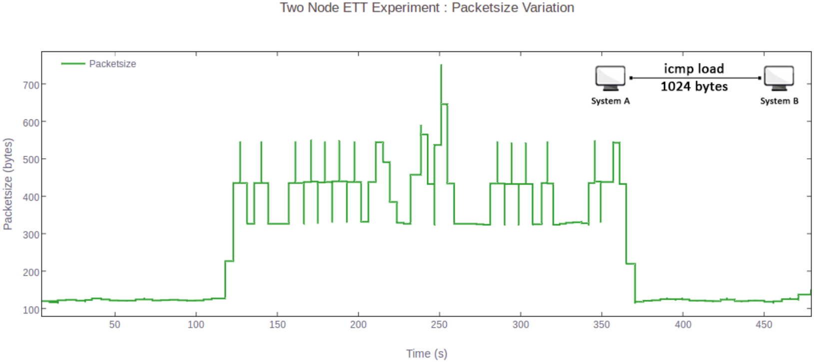

Figure 9 : Packetsize variation

Two node ETT experiment (2)

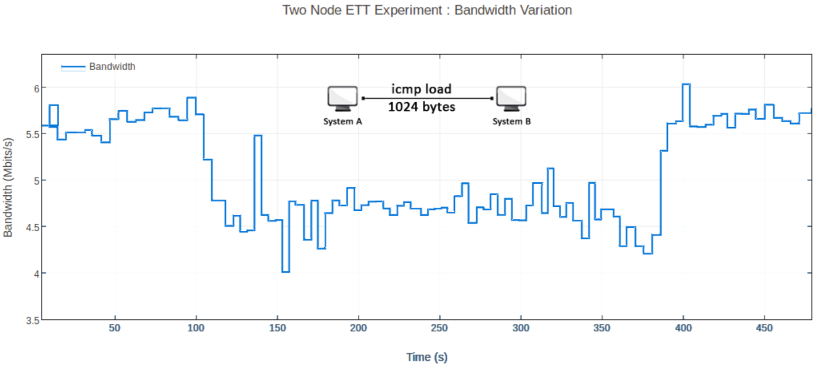

Figure 10 : Bandwidth variation

Two node ETT experiment(3)

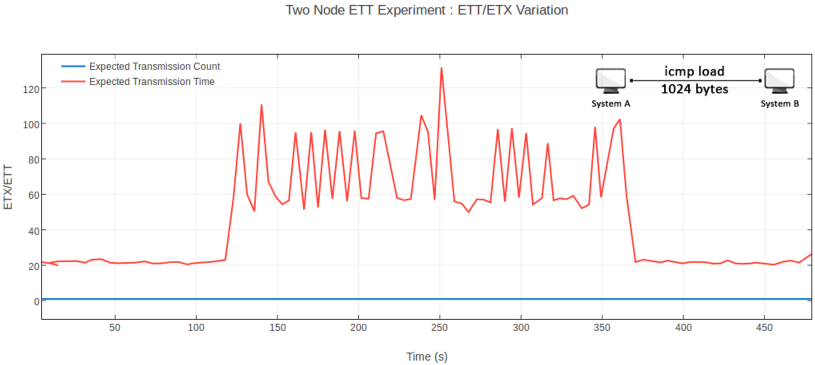

Figure 11 : ETX/ETT variation

ETT based Controller hand-off experiment(1)

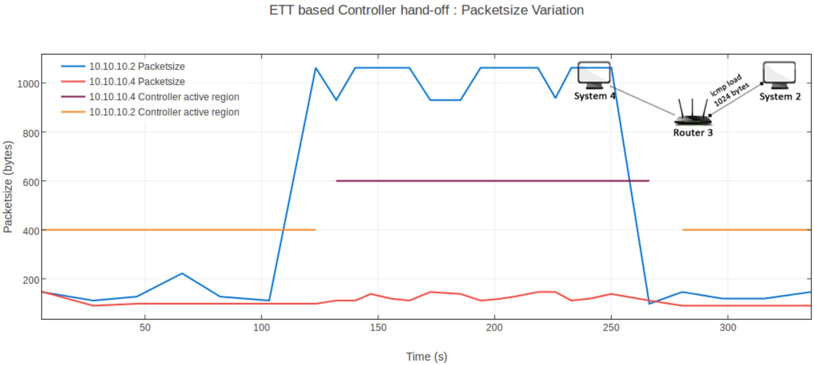

Figure 12 : Packetsize variation

ETT based Controller hand-off experiment(2)

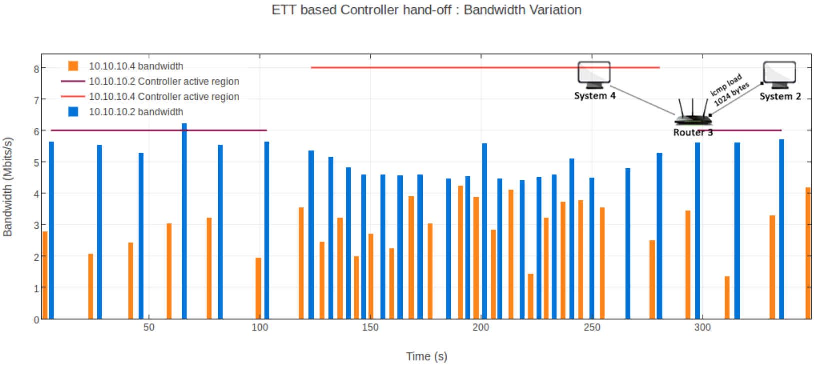

Figure 13 : Bandwidth variation

ETT based Controller hand-off experiment(3)

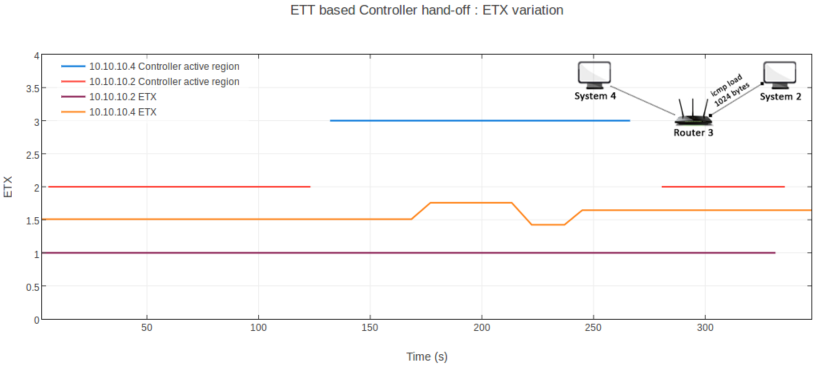

Figure 14 : ETX variation

ETT based Controller hand-off experiment (4)

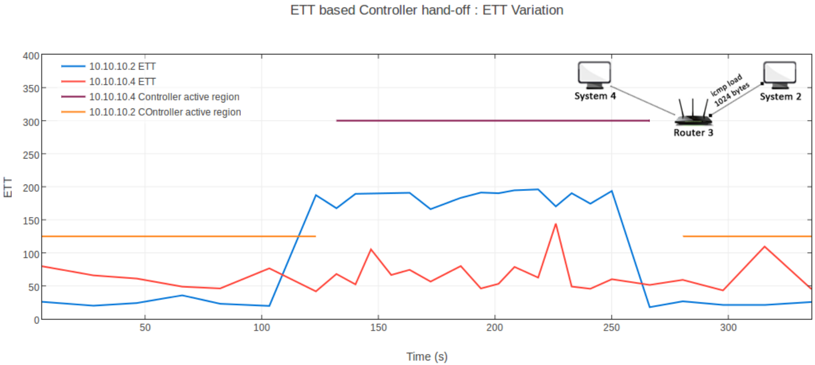

Figure 15 : ETT variation

ETT based mobile Controller hand-off experiment (1)

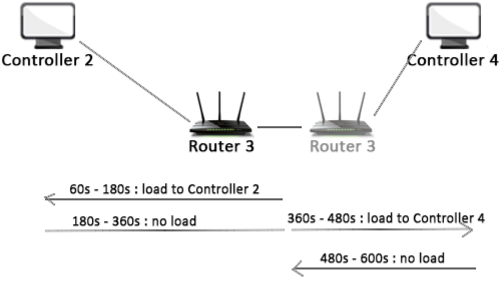

Figure 16 : Testbed

ETT based mobile Controller hand-off experiment (2)

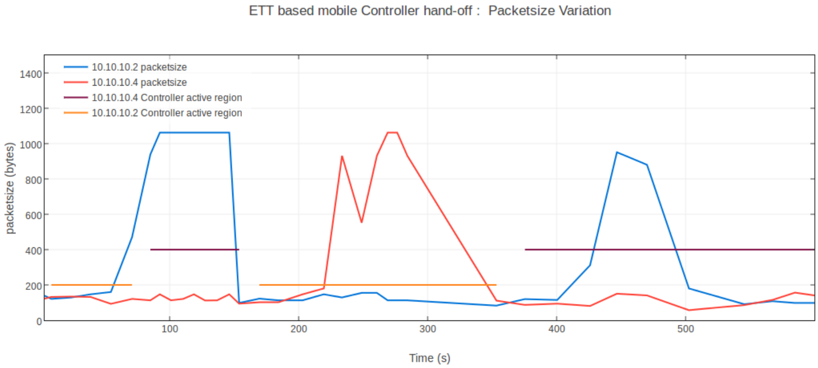

Figure 17 : Packet variation

ETT based mobile Controller hand-off experiment (3)

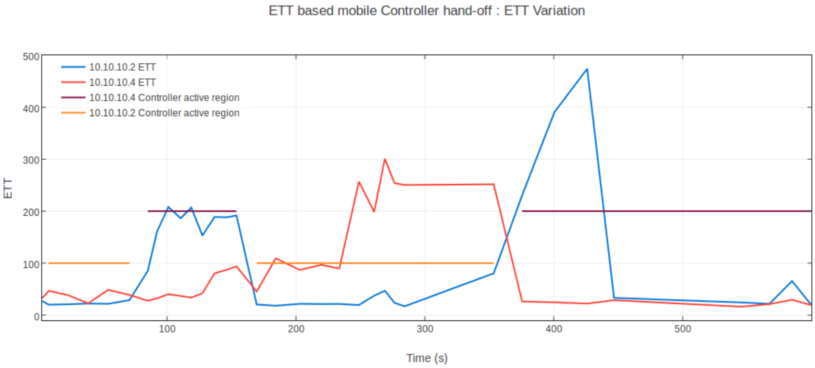

Figure 18 : ETT variation

Software defined MICRONet experiment (1)

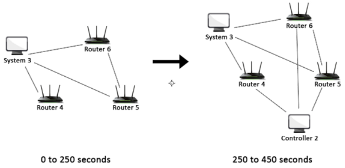

Figure 19 : Testbed

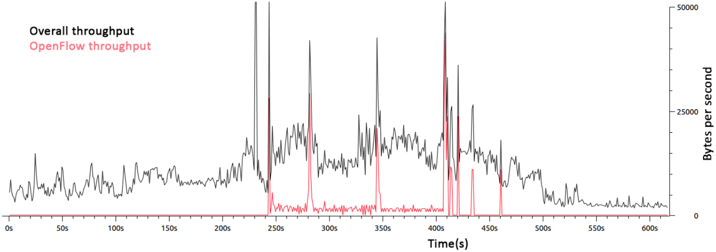

Figure 20 : Throughput analysis

Software defined MICRONet experiment (3)

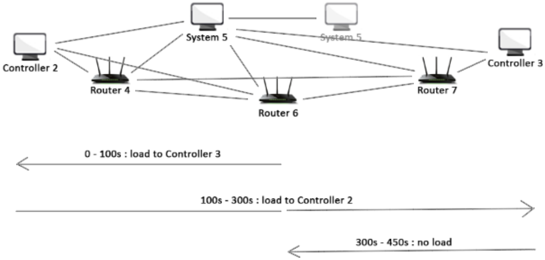

Figure 21 : Testbed

Software defined MICRONet experiment (4)

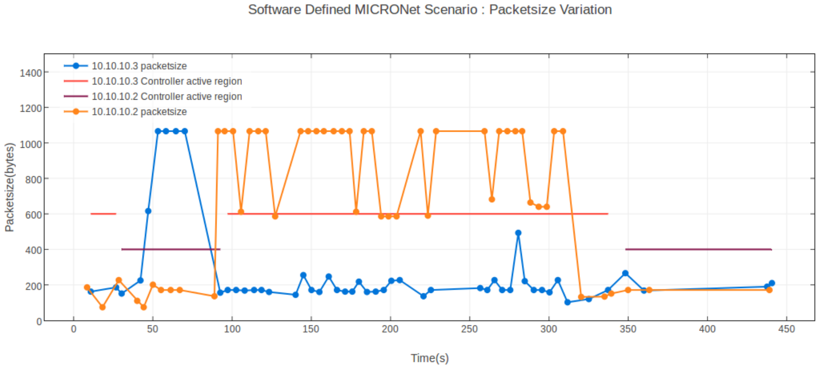

Figure 22 : Packetsize variation

Software defined MICRONet experiment (5)

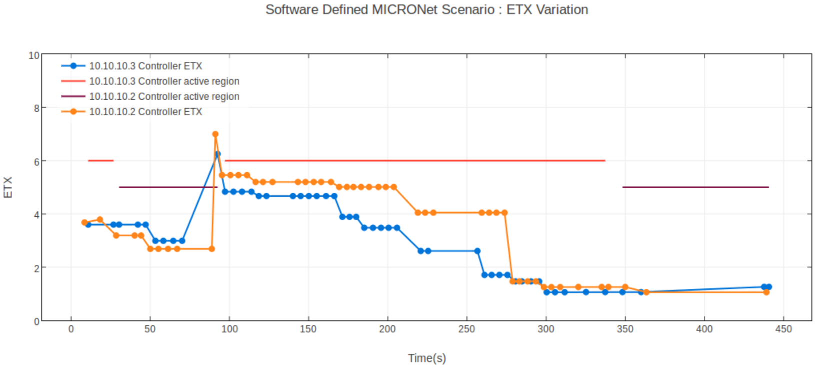

Figure 23 : ETX variation

Software defined MICRONet experiment (6)

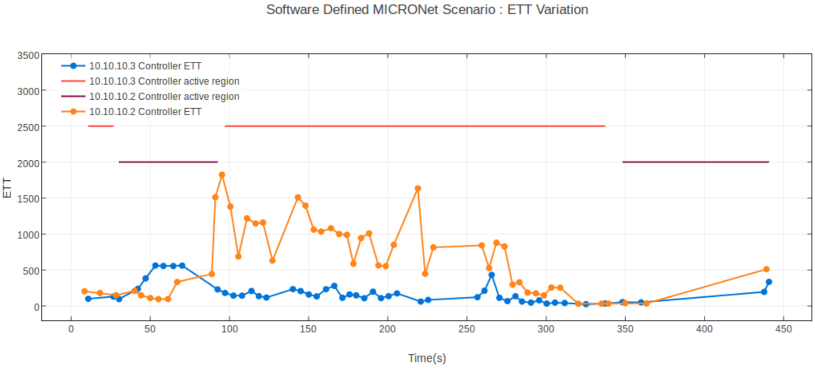

Figure 24 : ETT variation

Software defined MICRONet experiment (7)

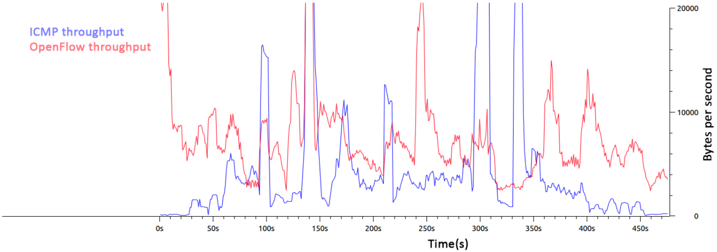

Figure 25 : Throughput analysis

Conclusion and Future work

1. Software Defined MICRONet achitecture provides intelligent communication among physical boat clusters in the sea
2. Developed an ETT-based controller section strategy
3. ETT-based controller selection performs better in mobile environments
4. Analysis of more scenarios helps to improve the strategy further
5. Incorporation of GPS/IRNSS into the Software defined MICRONet for futher intelligent architecture

Thank you.

amalrkrishna94@gmail.com