Improving Fault Tolerance in 802.11 Wireless Long Distance Rural Networks

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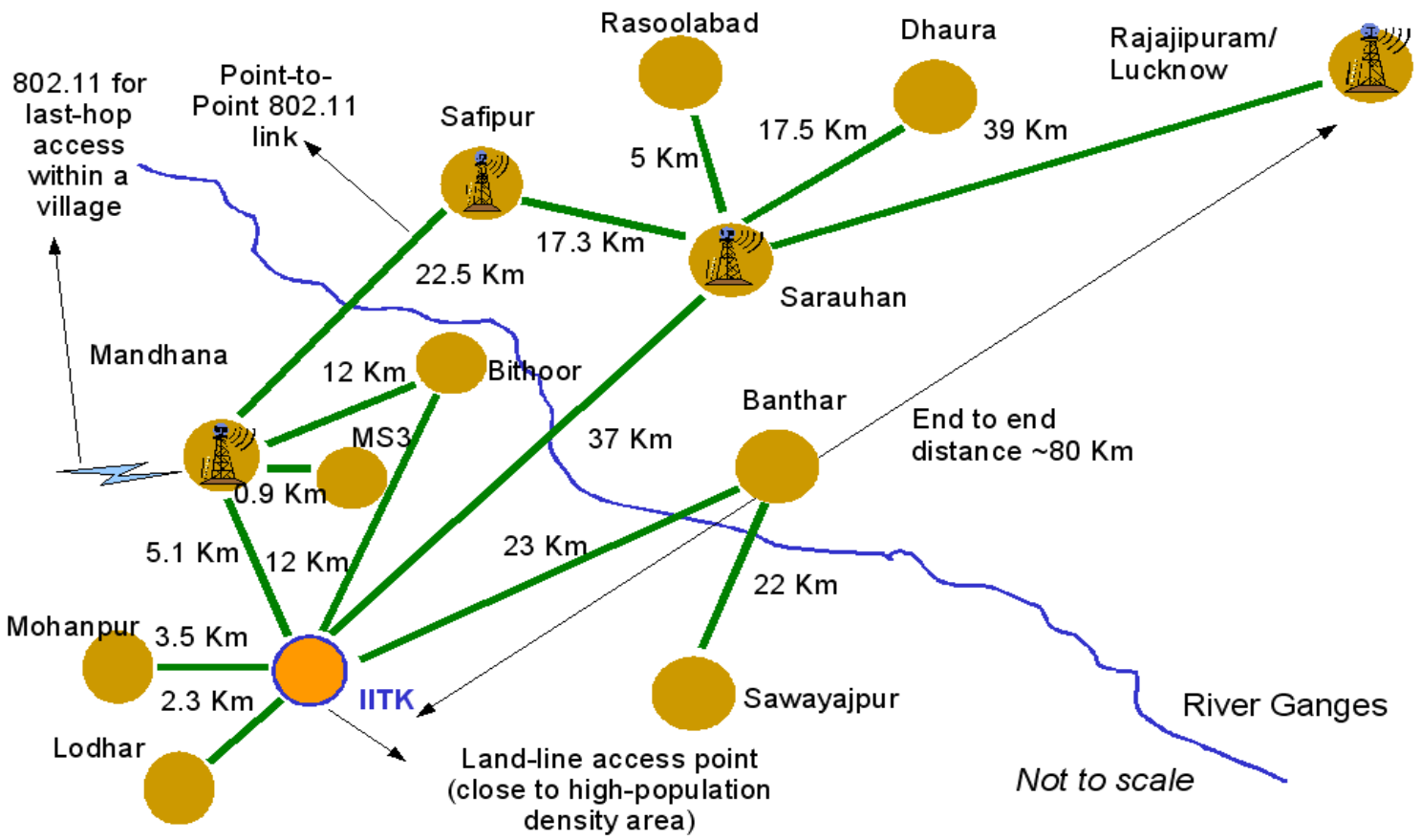
Motivation & Background

- More percentage of rural areas than urban areas in countries like India.
- Most of the rural areas are without any facilities of phone, internet....
- High cost of long distance wired networks than wireless networks to connect the rural areas.
- Increasing usage of wireless networks for connecting rural areas.
- Network Disconnection due to problems at one or more nodes (e.g. power failure).

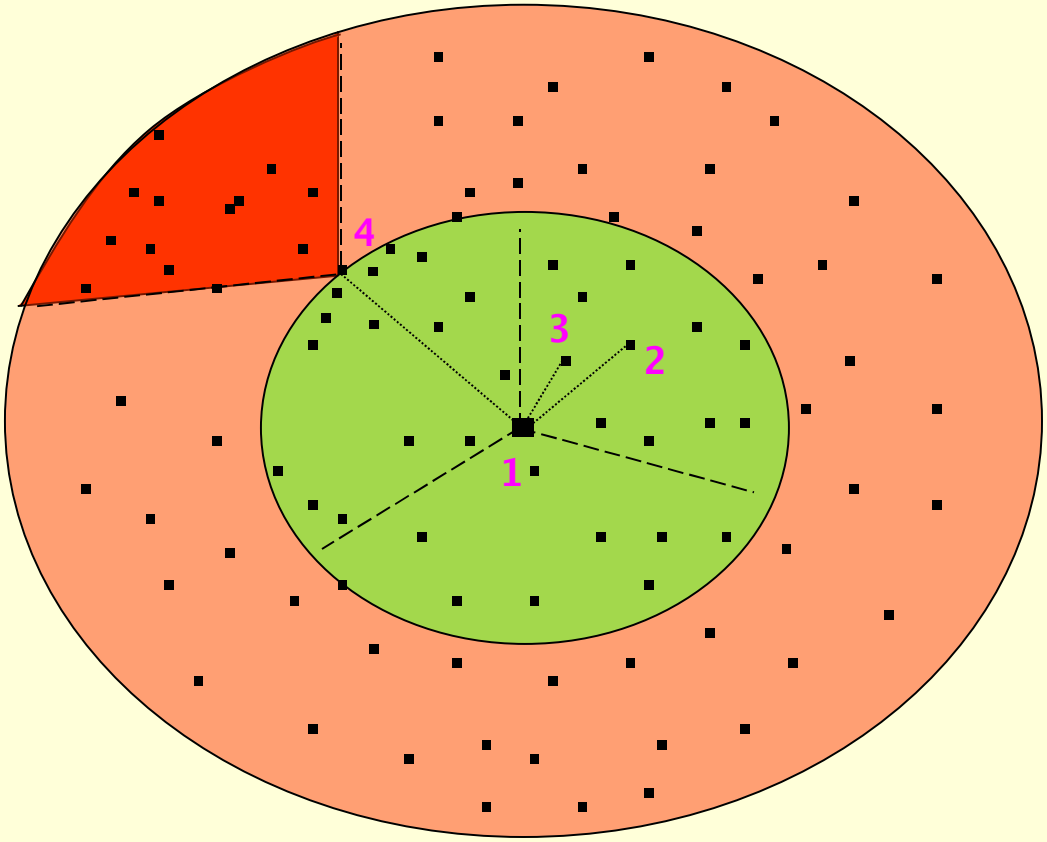
Motivation & Background

Digital Gangetic Plains

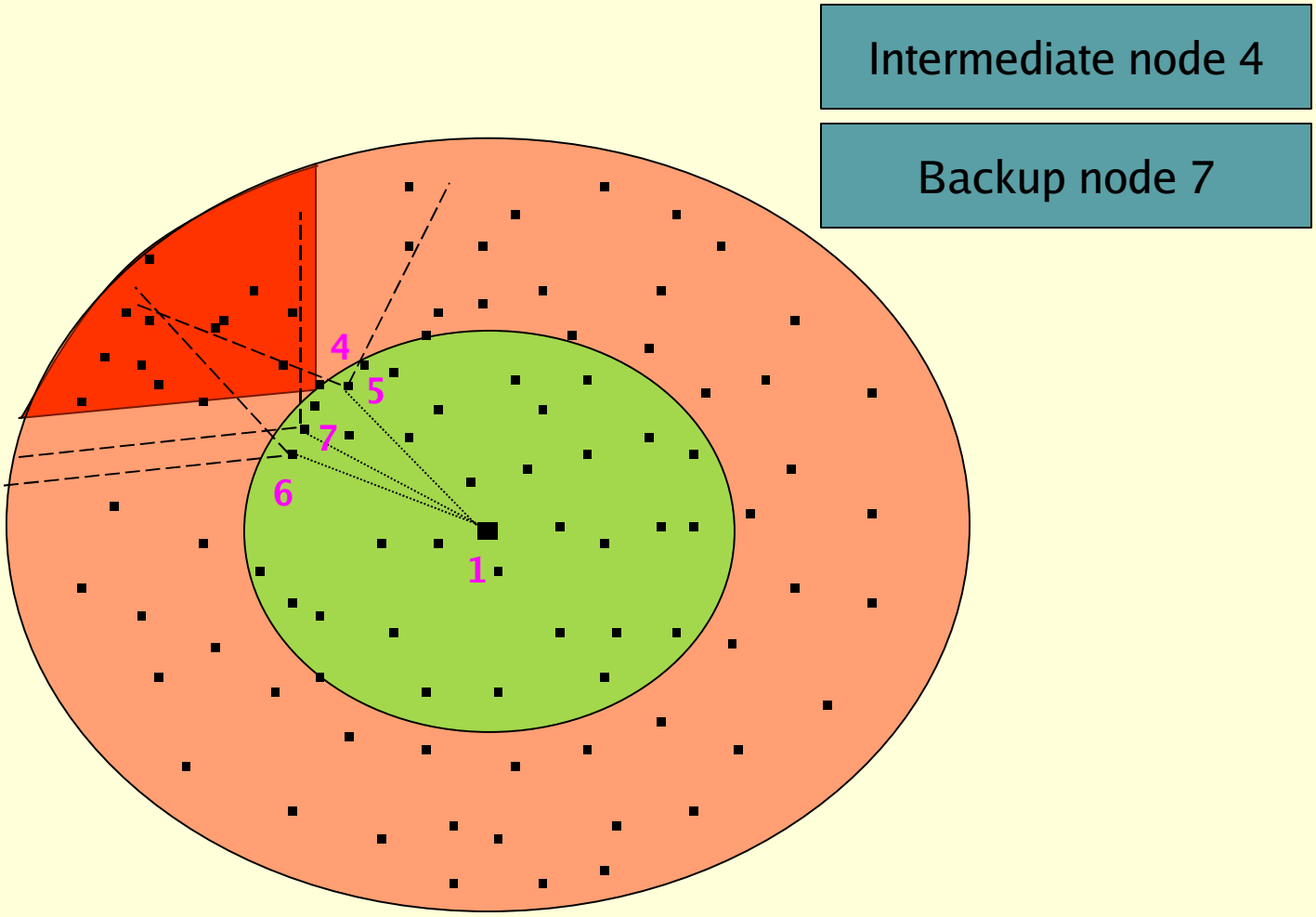


Problem Statement

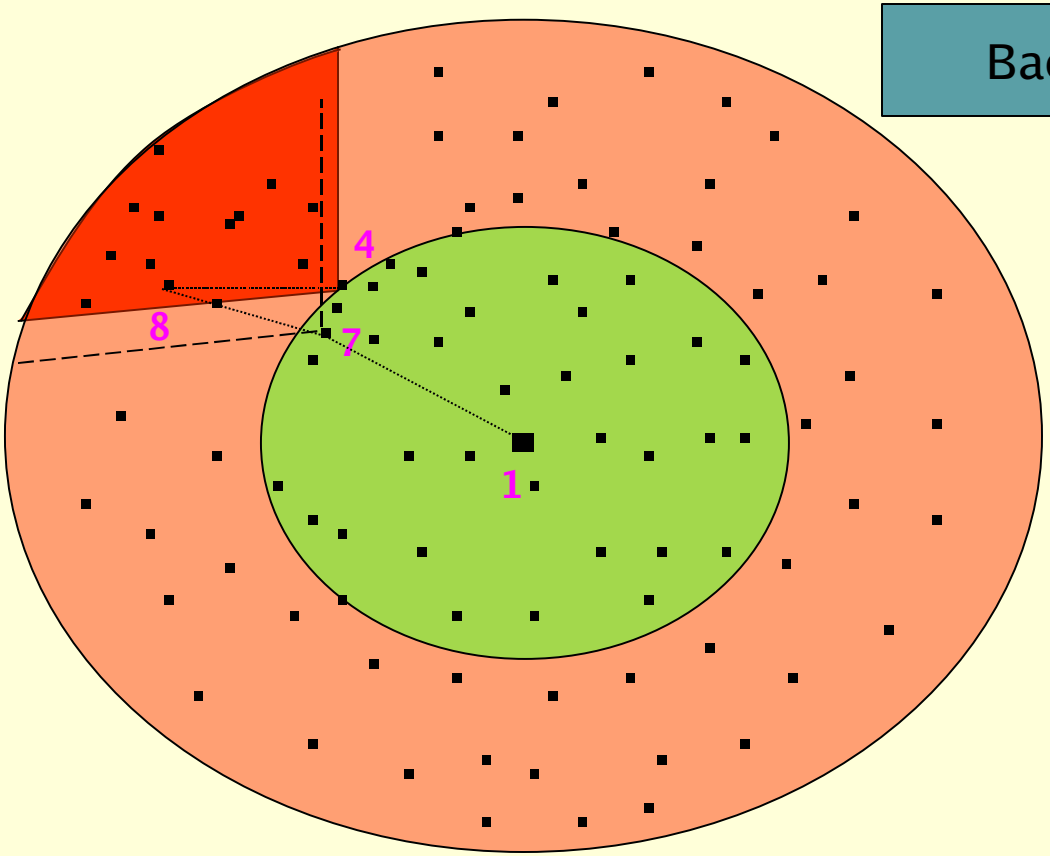
Intermediate node 4



Problem Statement



Problem Statement



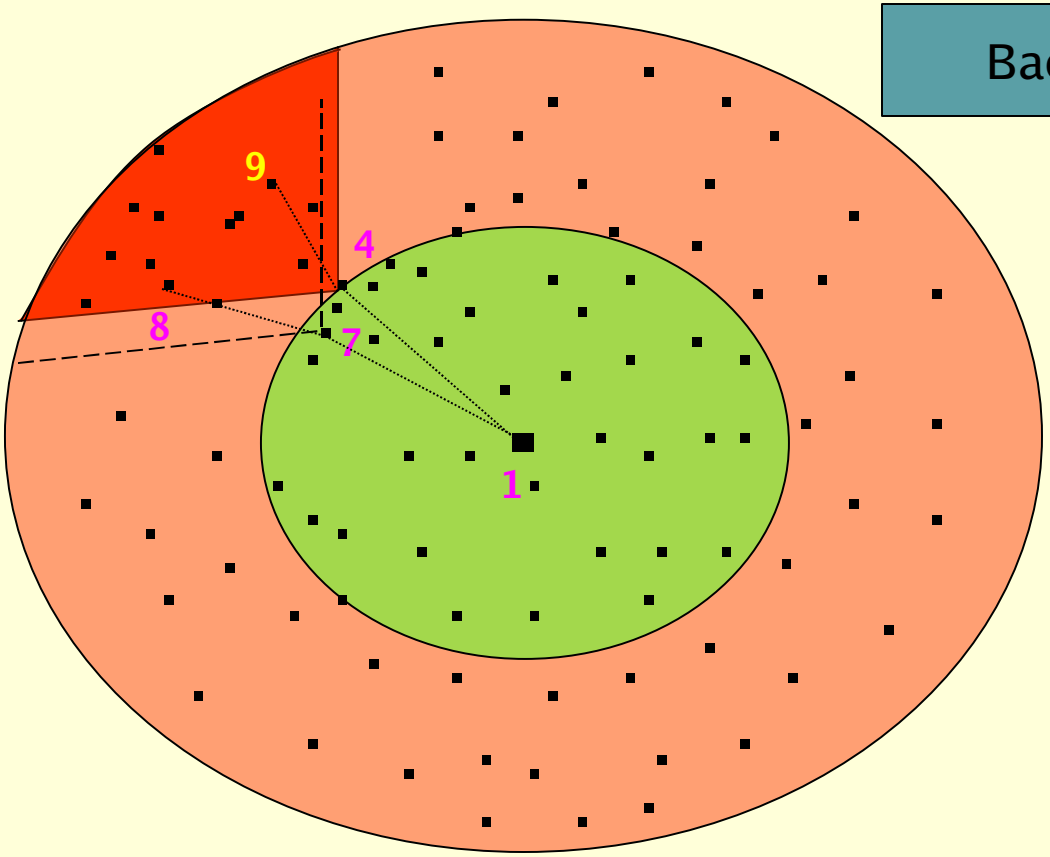
Intermediate node 4

Backup node 7

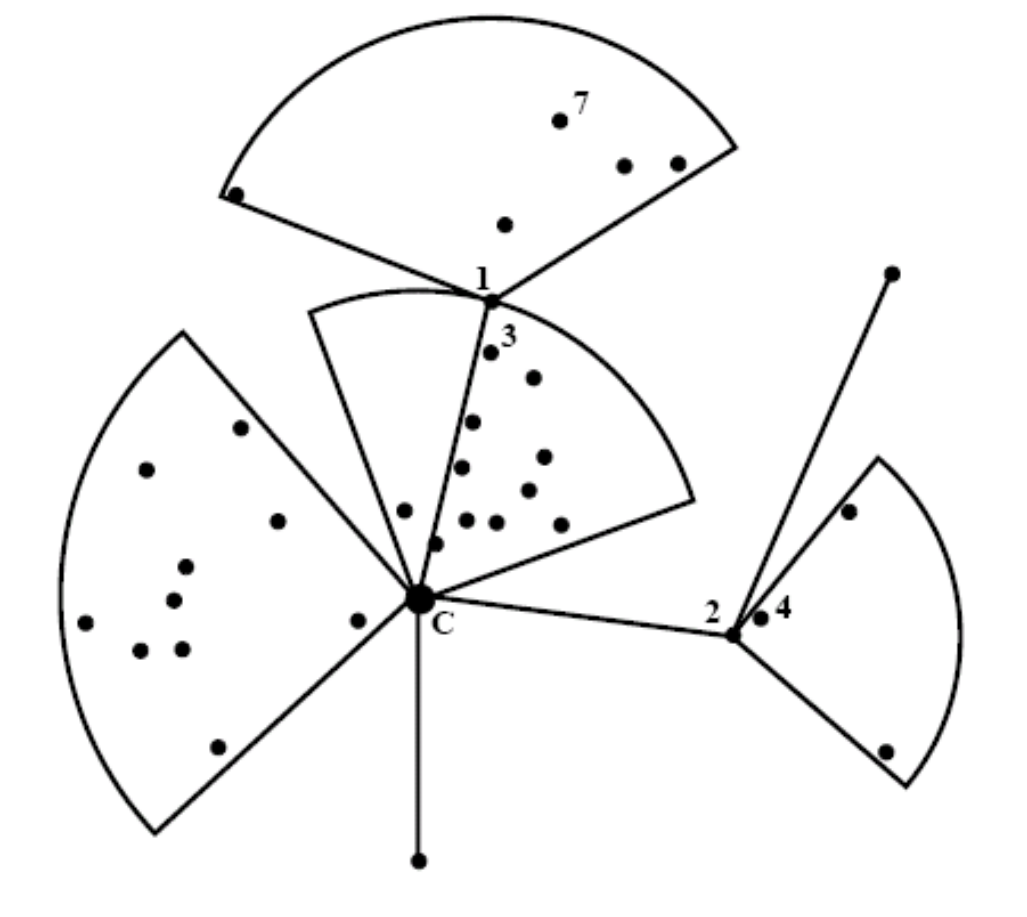
Advantage

Intermediate node 4

Backup node 7



Ashwini Network



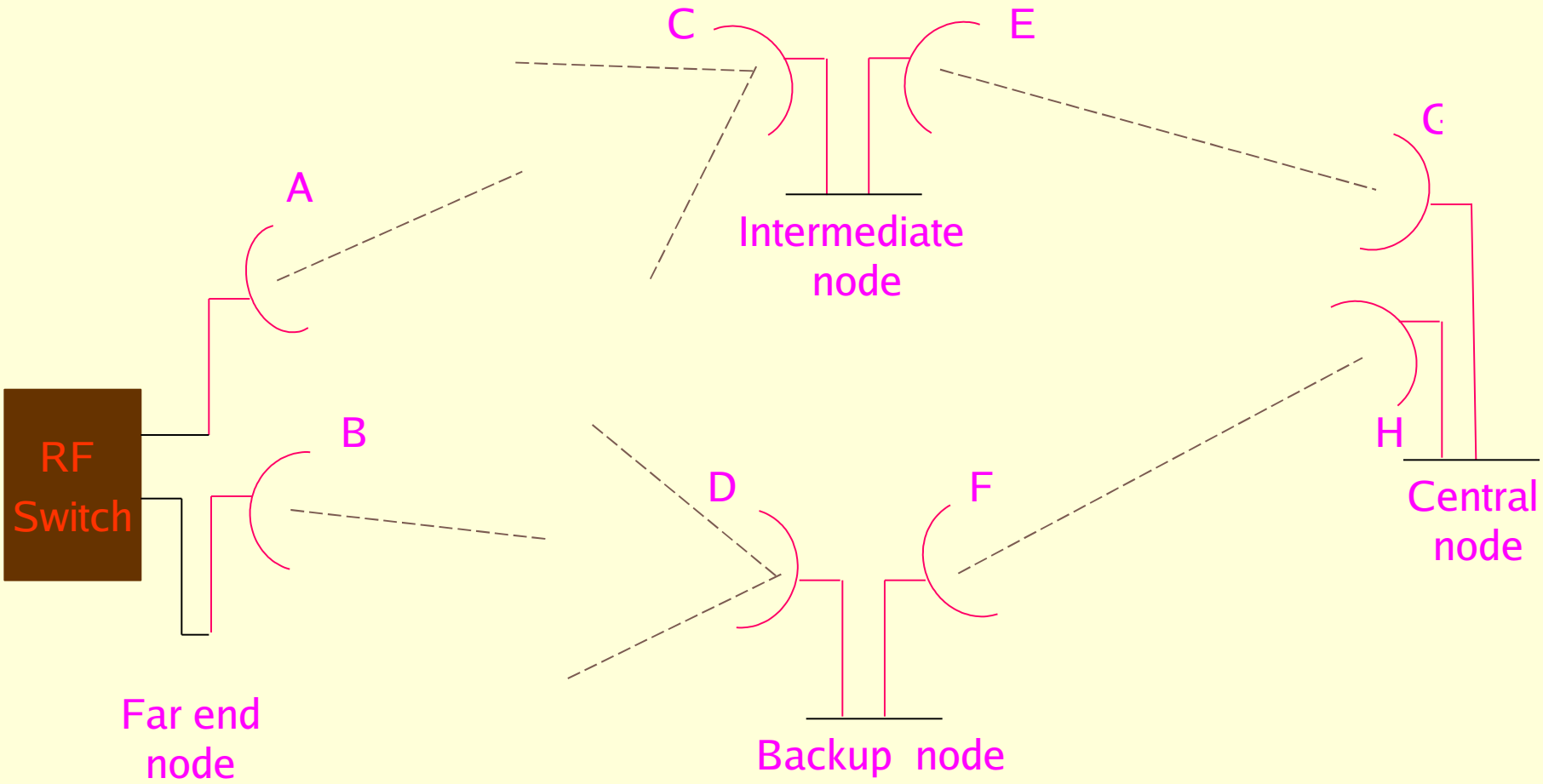
Design Issues

- Three possible ways of changing the link
  - Replication of directional antennae and switching between them.
  - Using a Stepper Motor to rotate the directional antenna.
  - Using a sector antennae (cantenna).

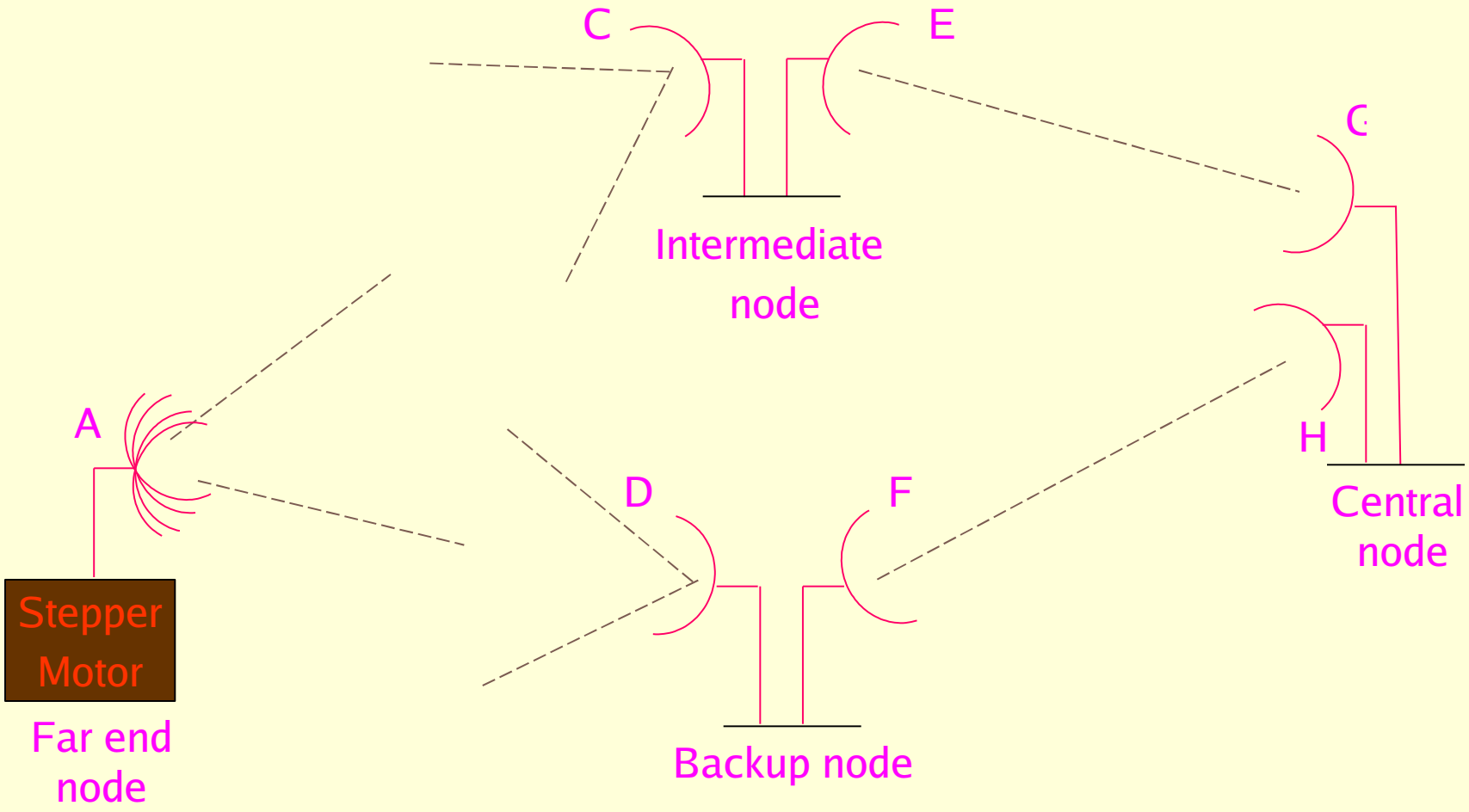
Related Work

- Community networks
  - MIT Roofnet
    - Omni directional antenna
    - Routing problem only
  - Wireless Leiden
    - Multiple radios and antennae
    - Routing problem
- Ad-hoc networks with directional antennae.
  - Multiple directional antennae at nodes
  - Routing problem
  - Not implemented.

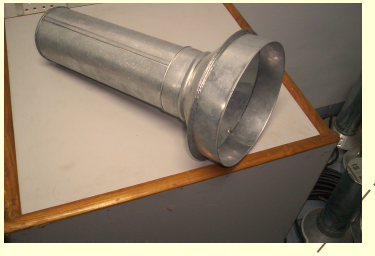
Replication



Rotation


C
E
G
Intermediate
node
A
H
D
F
Central
node
Stepper
Motor
Far end
node
Backup node

Cantenna



C
E
Intermediate node
A
Far end node
D
F
Backup node
H
Central node

Thesis Contributions

- Implemented Replication and Cantenna solutions.
- Partially implemented Rotation solution.
- Evaluated and documented performance and cost issues of the solutions.

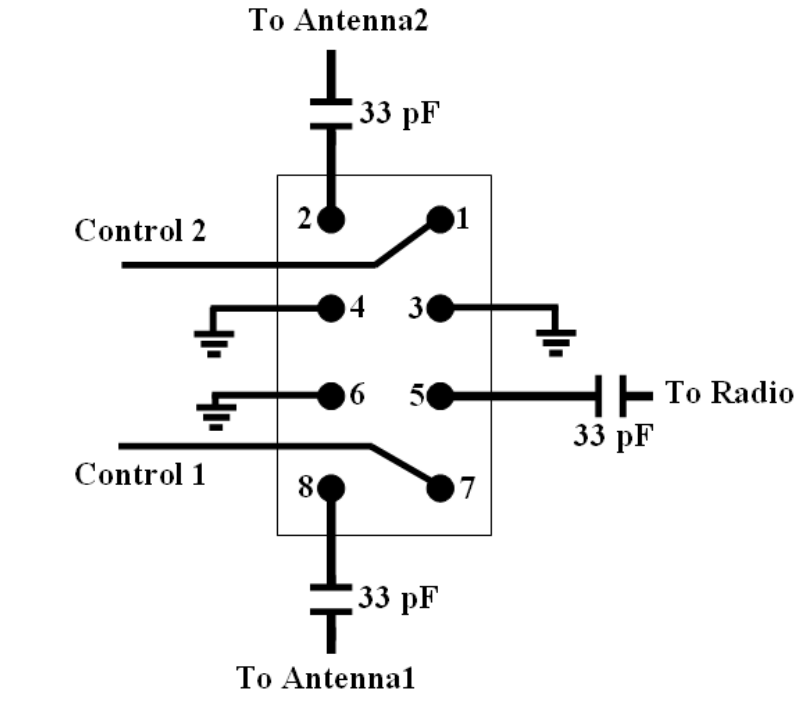
Design and Implementation

- Replication:
  - PSW-1211 switch circuit.
  - RSW-2-25-P switch circuit.
  - Hardware for generating control signals.
  - Software sending control logic to hardware.
- Rotation:
  - Circuit to interface the stepper motor.
  - Software to rotate the motor in full step and half steps.
  - Antenna mounting to the motor.
- Cantenna:
  - Software to switch the link.

Design and Implementation

Replication:

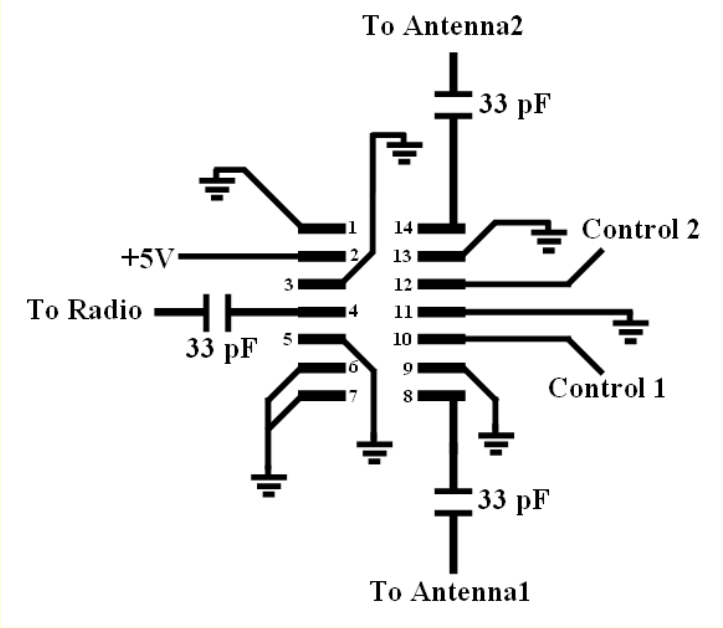
PSW-1211 switch circuit



Design and Implementation

Replication:

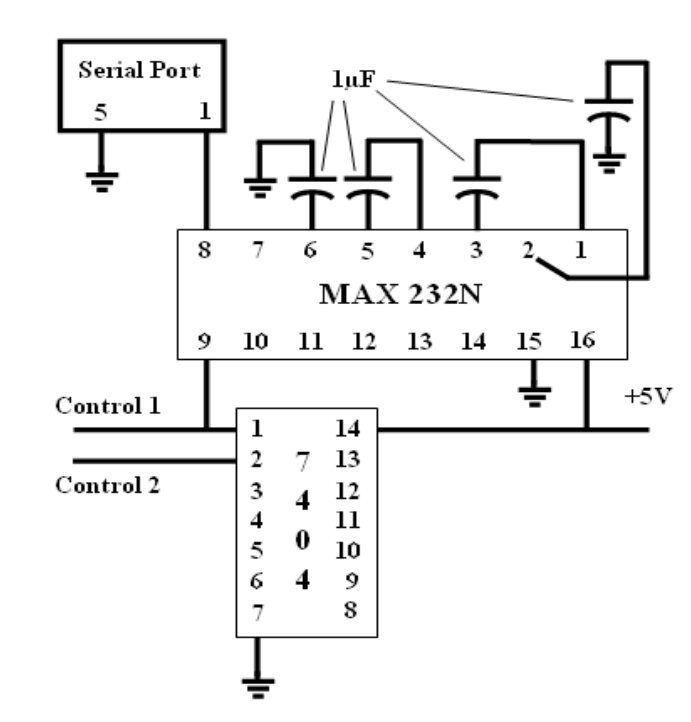
RSW-2-25-P switch circuit



Design and Implementation

Replication:

Hardware for control signals



Design and Implementation

Replication:

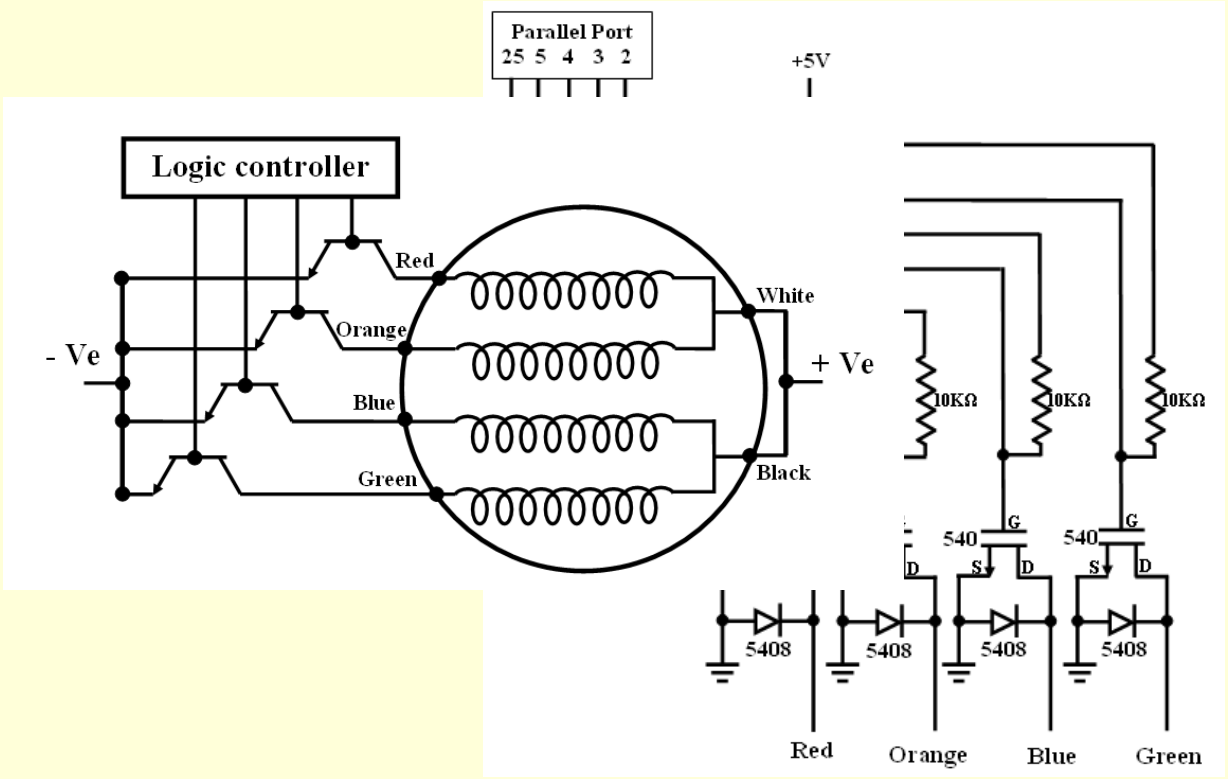
Software

	Serial Port Baud rate
Logic ‘0’	0
Logic ‘1’	Higher than 0

Design and Implementation

Rotation:

Interface circuit for motor



Design and Implementation

Rotation:

Control logic sequence

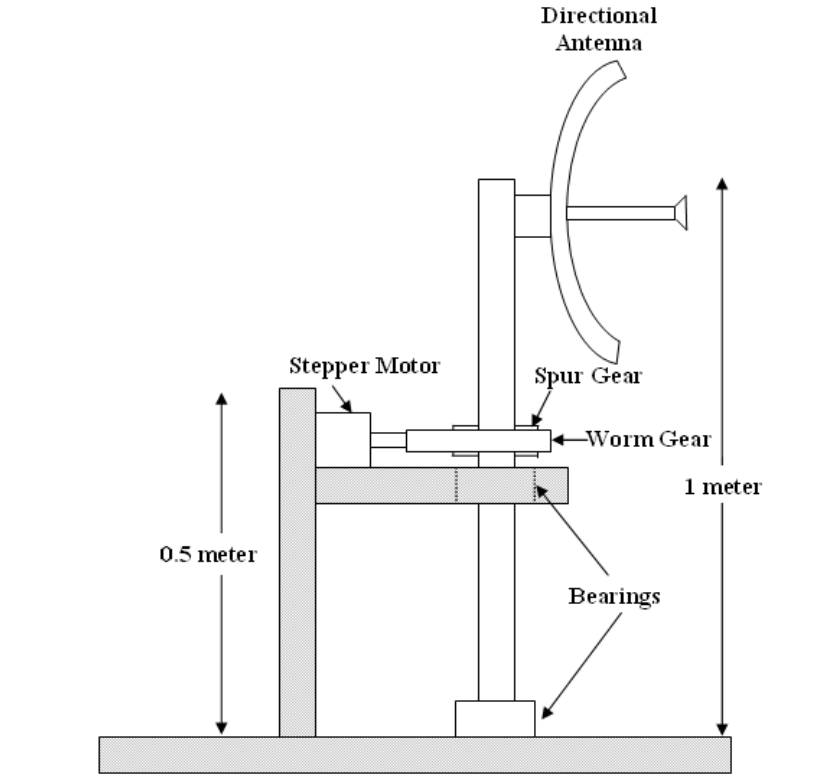
Full Step (1.8°)			
Red	Orange	Blue	Green
0	1	0	1
0	1	1	0
1	0	1	0
1	0	0	1

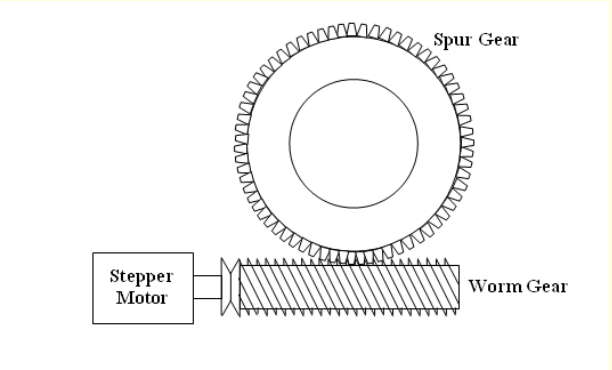
Half Step (0.9°)			
Red	Orange	Blue	Green
0	1	0	1
0	0	0	1
1	0	0	1
1	0	0	0
1	0	1	0
0	0	1	0
0	1	1	0
0	1	0	0

Design and Implementation

Rotation:

Antenna Mounting





Design and Implementation

Cantenna:

Software:

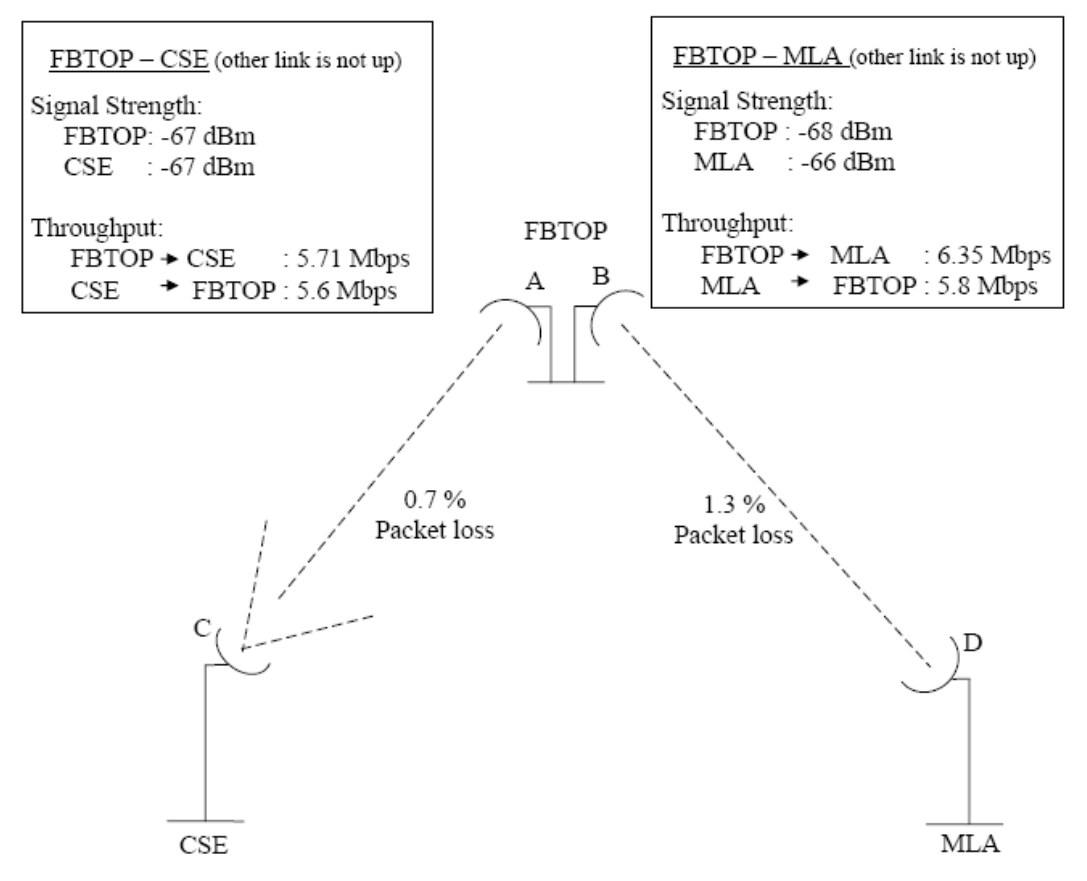
- Software to change the link is done by using commands (monitoring link using ‘ping’ & changing the wireless link)

Evaluation

- Two links FBTOP – CSE and FBTOP – MLA.
- FBTOP:
  - Two directional Antenna:
    - MLA:- beam width 13^{o} and Gain 22.5 dBi
    - CSE :- beam width 8^{o} and Gain 24 dBi
- MLA:
  - One directional Antenna with beamwidth 13^{o} and Gain 22.5 dBi.
- CSE:
  - One sector Antenna with beamwidth 65^{o} and Gain 12 dBi.
  - Attenuator (28 dB)
- One Laptop and prism chipset based *Senao* wireless card at each place.
- Hostap driver 0.4.7 and hostap utils 0.3.7.

Evaluation

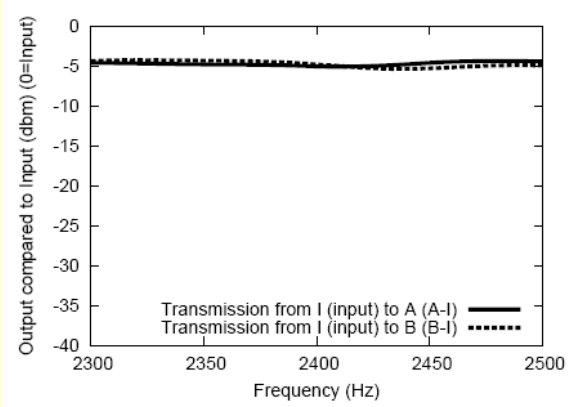
Preliminary:

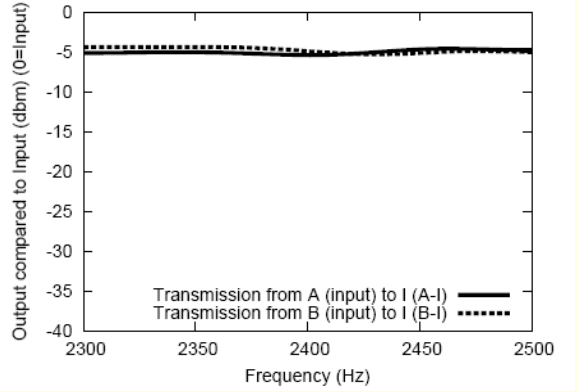


Evaluation

Replication (PSW-1211):

Calibration - Transmission:

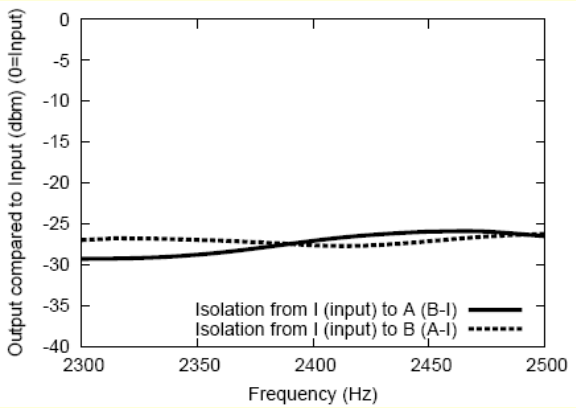


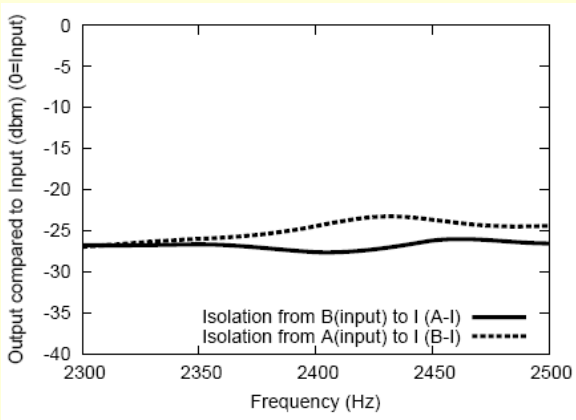


Evaluation

Replication (PSW-1211):

Calibration - Isolation:





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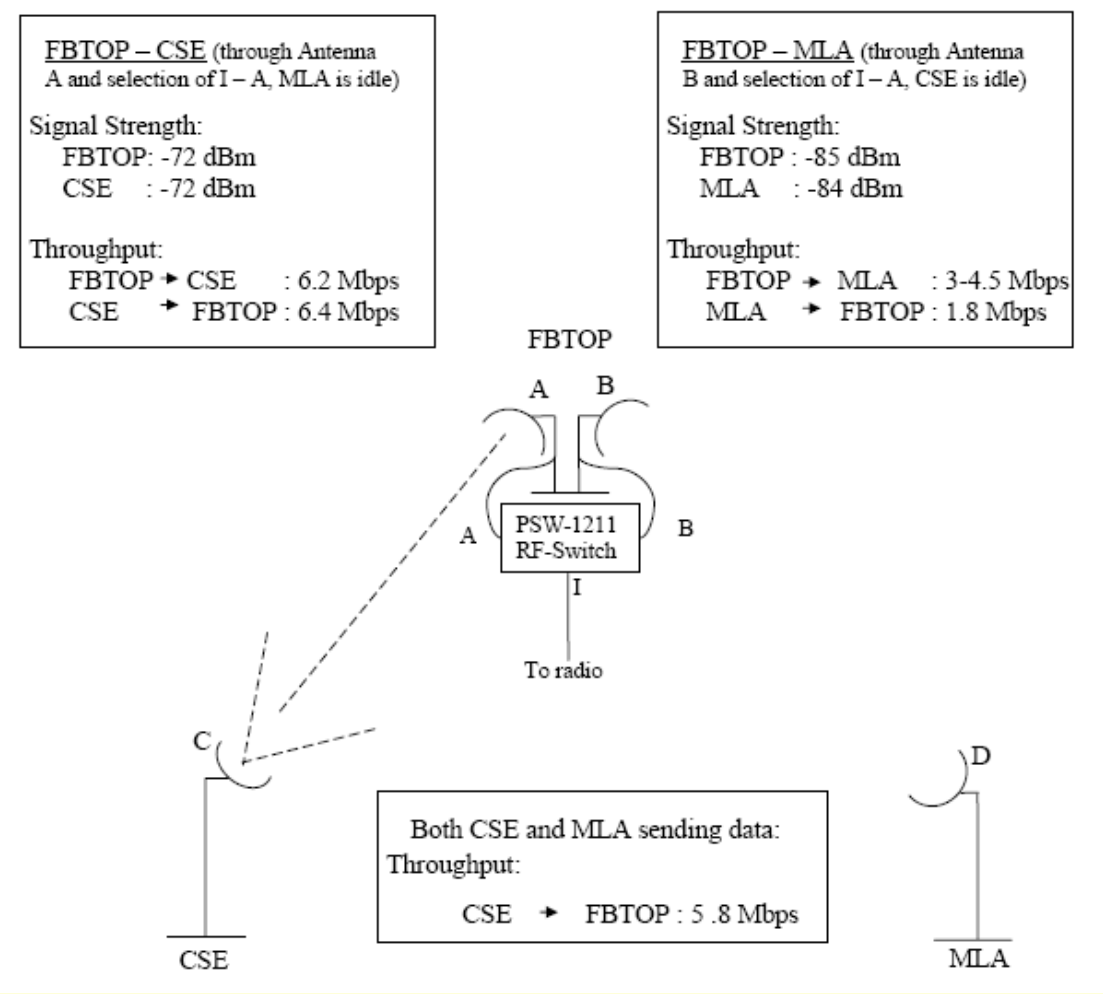
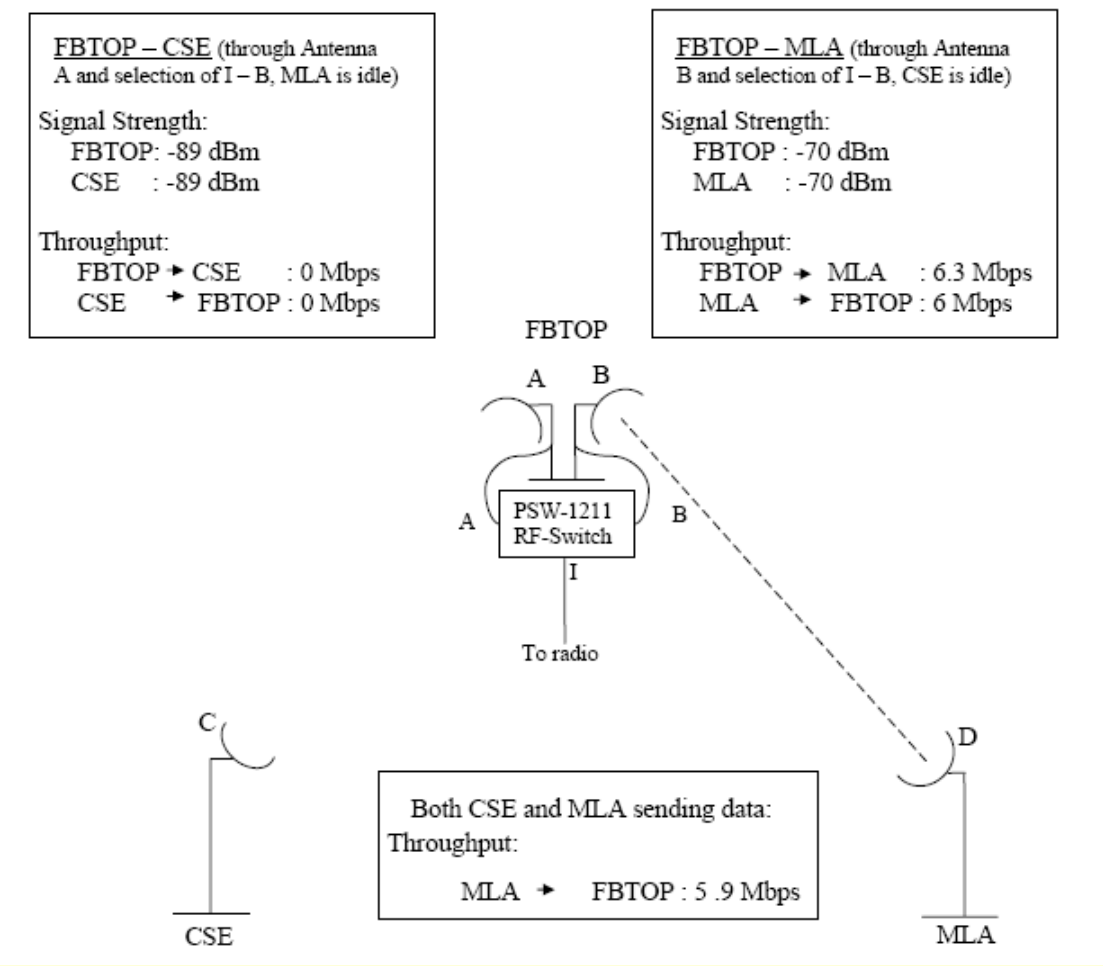
Replication (PSW-1211):



Evaluation

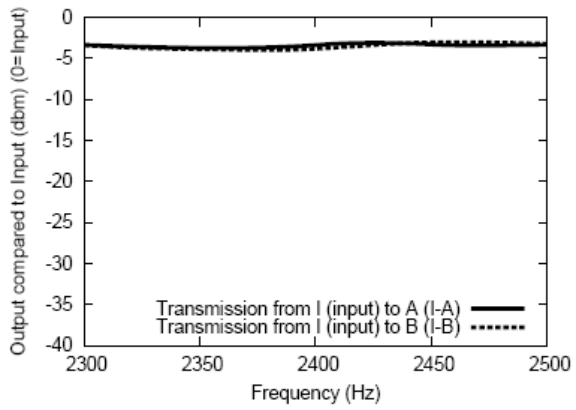
Replication (PSW-1211):

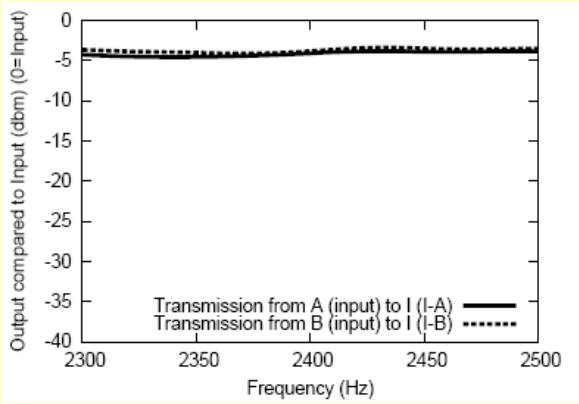


Evaluation

Replication (RSW-2-25-P):

Calibration - Transmission:

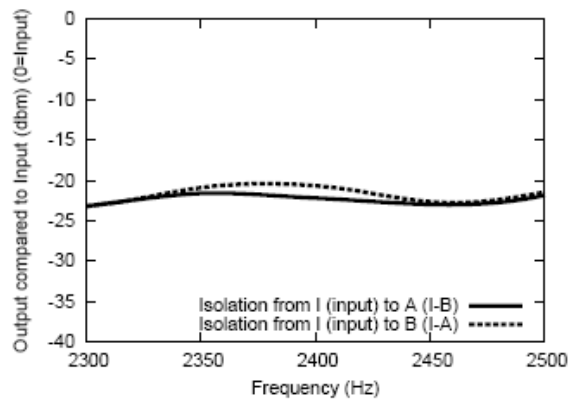


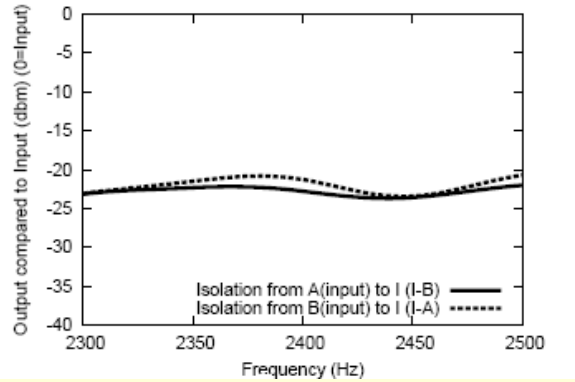


Evaluation

Replication (RSW-2-25-P):

Calibration - Isolation:





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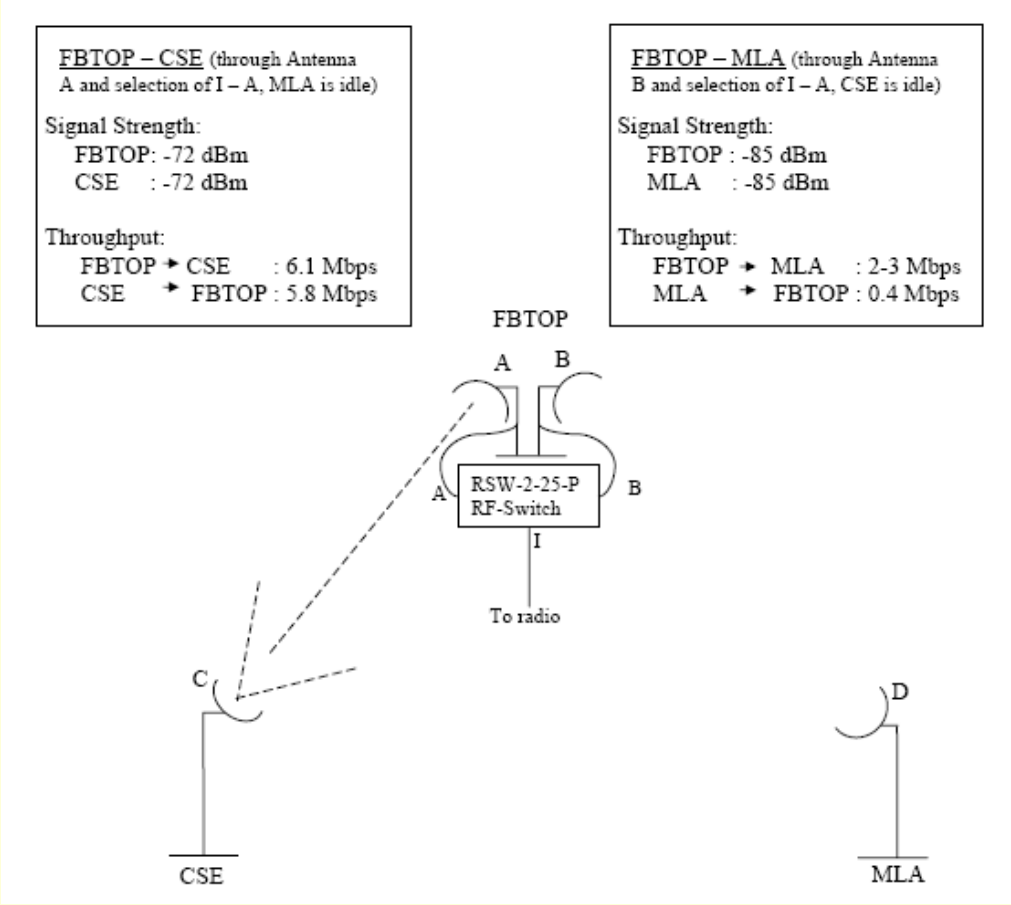
Replication (RSW-2-25-P):



Evaluation

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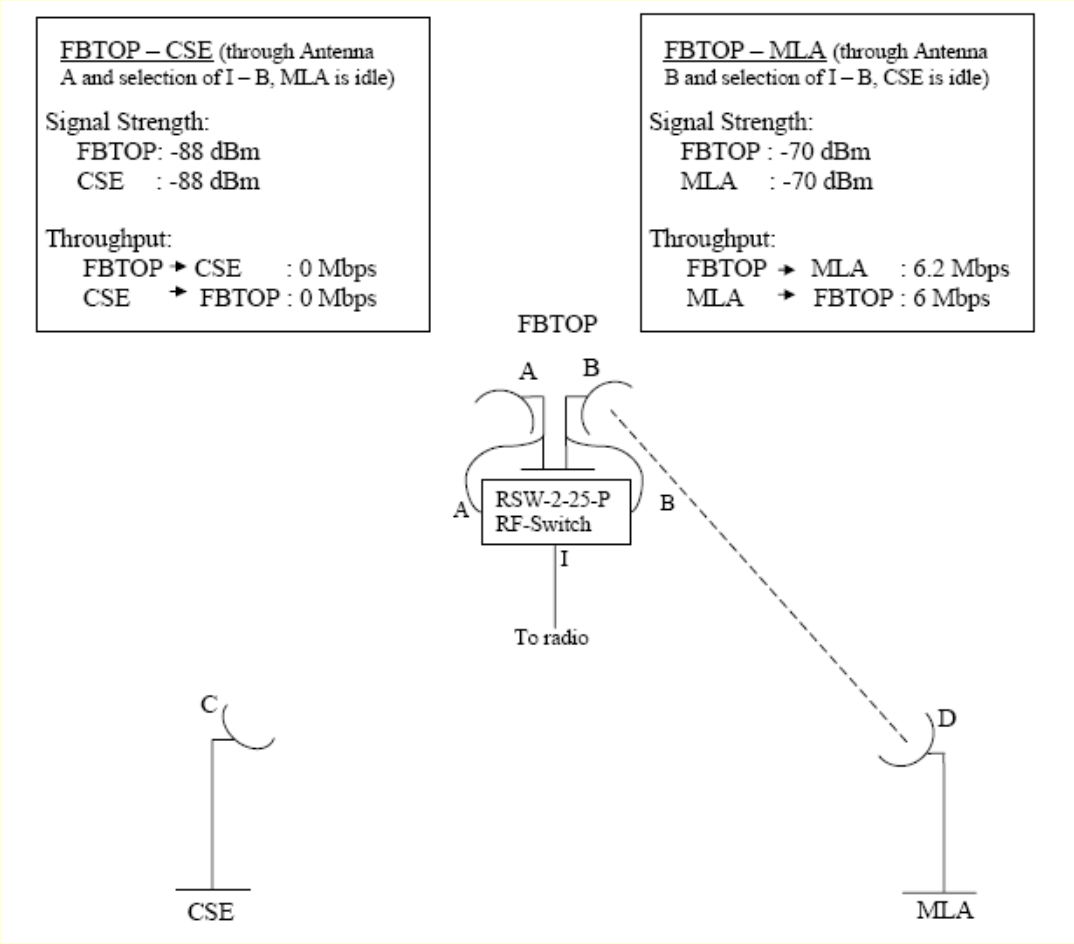
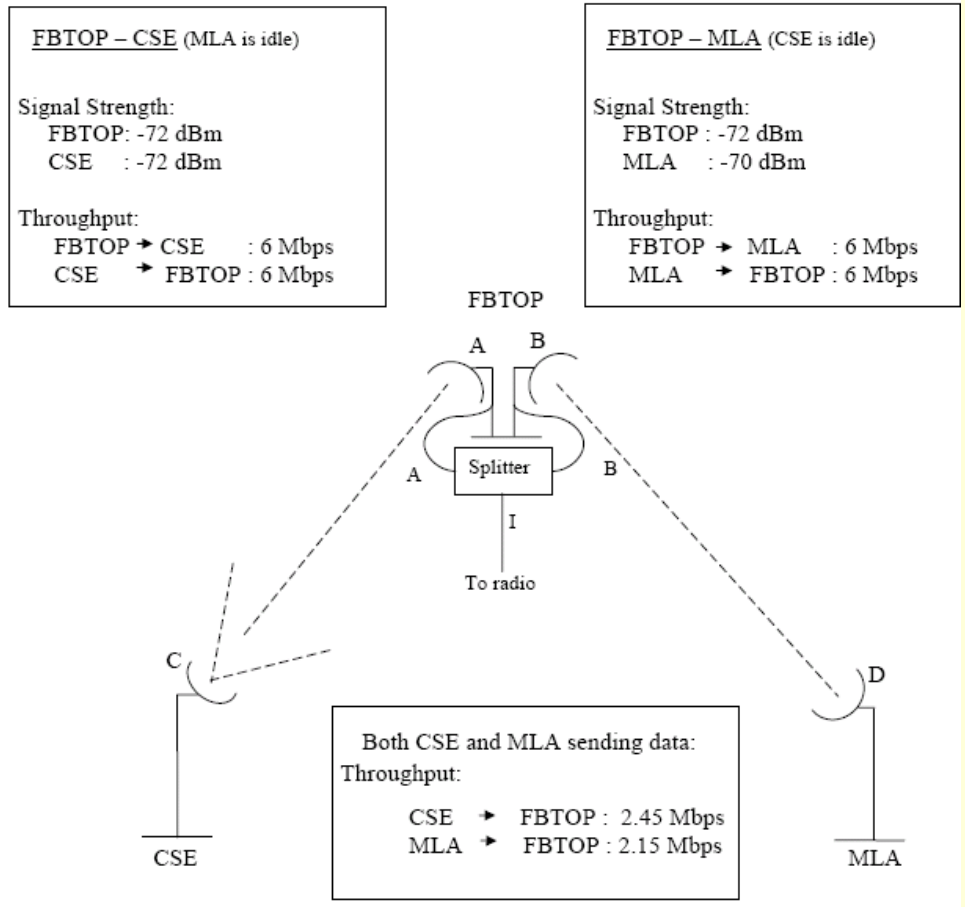


Evaluation

- Rotation:
  - Interface circuit and software for rotation are implemented.
  - Antenna mounting not implemented.
  - Will be same as Preliminary case.

Evaluation

- Cantenna:
  - Implemented using a Splitter.



Comparison

	Preliminary	Replication		Rotation	Cantenna
		PSW-1211	RSW-2-25-P		
No. of Antenna	N/A	2		1	1
Switching Time	N/A	Order of micro seconds		Order or minutes	Order of micro seconds
Interference from other link	Negligible	17 dB less than other link signal strength		Negligible	Equal to signal strength
FBTOP – CSE	5.7 Mbps	6.2 Mbps	6.1 Mbps	5.7 Mbps	6 Mbps
FBTOP – MLA	6.2 Mbps	6.3 Mbps	6.2 Mbps	6.2 Mbps	6 Mbps
At FBTOP when CSE and MLA are transmitting data	N/A	5.8 Mbps	Will be same as PSW-1211	6 Mbps	2.4 Mbps
Cost	N/A	2*$50+$33	2*$50+$4	$50+$59	$10

Conclusion

- Presently no cost-effective solutions.
- Presented and implemented three solutions Replication, Rotation (partially implemented) and Cantenna.
- Replication and Rotation are good for all cases.
- Cantenna is good only when one of the intermediate node or backup node is serving the far-end nodes.

Future Work

- Assumed that intermediate and backup nodes are given.
- Find the intermediate and backup nodes optimally.
- Rotation has to be implemented completely.

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