Scalable Routing for Mechanical Backhaul Networks

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Outline

- Motivation
- Background
- Problem Definition
- Scalable Routing Architecture
- Evaluation
- Future Work
- Conclusion

MOTIVATION

Motivation: Rural Connectivity

- E-governance
- Transfer of knowledge
- Exposure to the world wide web
- E-health care
- Business

Reference:
www.csdms.in/.../Presentations/Day%20II/UNDP%20ICTD/Project%20Ashwini,%20Byrraju%20Foundation.pdf

Motivation: Rural Connectivity

- Ashwini Project – Bhimavaram
  - Virtual delivery of
    - Health care
    - Education and Adult Literacy
    - Livelihood training
    - Governance
  - 28 villages, 500,000 people

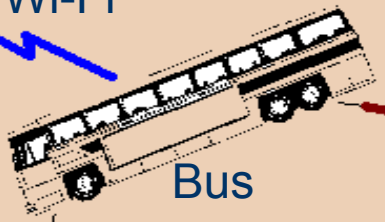
Reference:
www.csdms.in/.../Presentations/Day%20II/UNDP%20ICTD/Project%20Ashwini,%20Byrraju%20Foundation.pdf

BACKGROUND

Background: Delay Tolerant Networks

Village

Wi-Fi



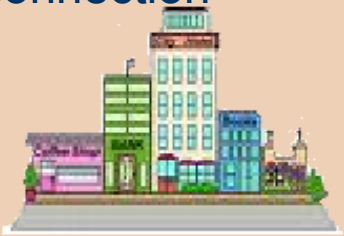
Bus

Delay Tolerant Networks

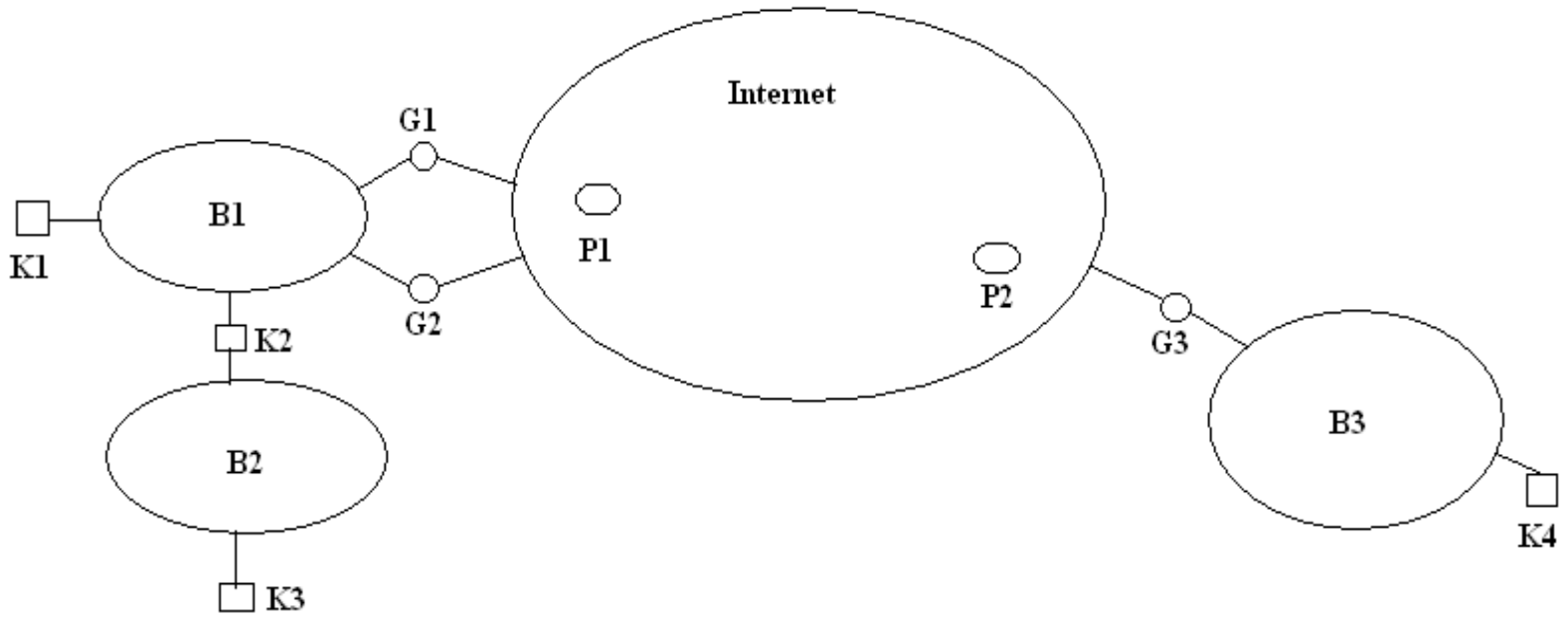
When a ferry (e.g. single board computer on a Bus) comes in vicinity of a kiosk, the kiosk transfers the data it has to the ferry. The ferry in turn dumps the data on a gateway (connected to Internet) when it reaches a town/city.

Images from google image search.

Town/City with Internet connection



Background: Mechanical backhaul networks



PROBLEM DEFINITION

Problem Setting: India as case in point

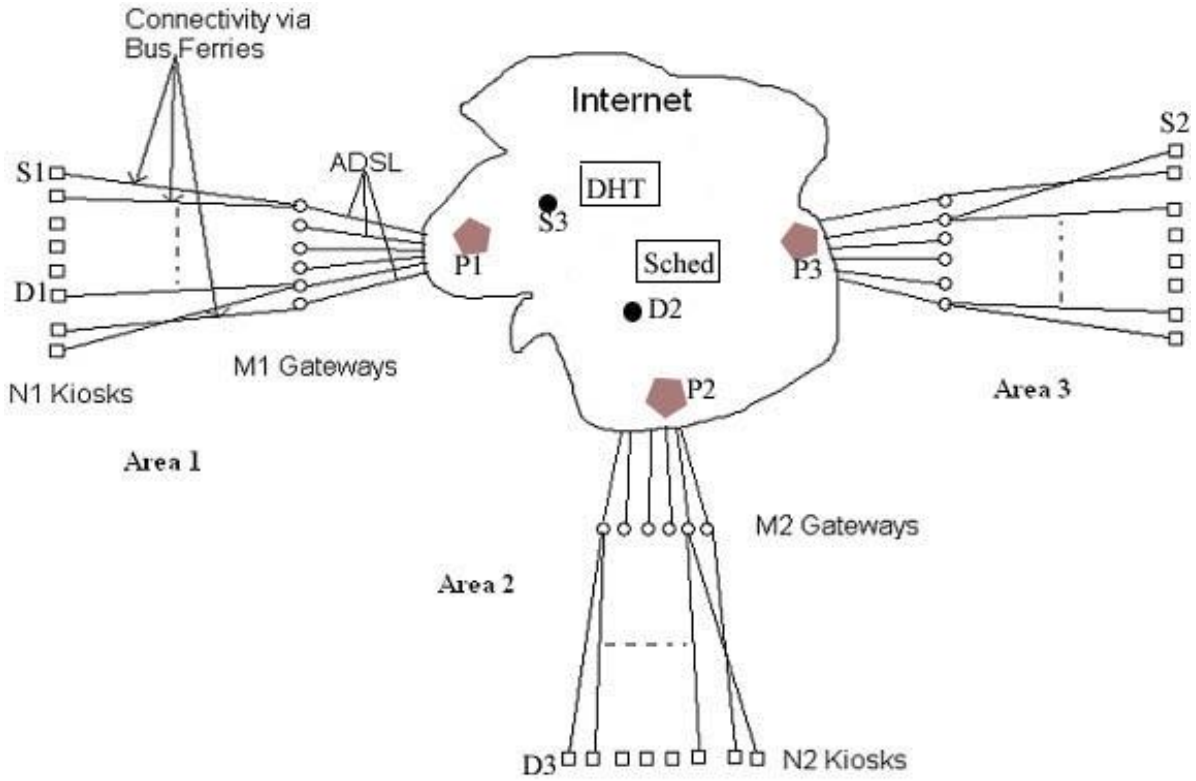
- Low capacity Internet connectivity at district headquarters
- Good bus connectivity to villages
- Low cost requirement

Problem Definition

- Design, implement and evaluate a routing protocol for mechanical backhaul networks with the following properties
  - Scales to country wide networks (order of 100K nodes)
  - Gives high delivery ratio; it is robust.
  - Uses bottleneck Internet links minimally.
  - Minimizes cost of deployment

SCALABLE ROUTING ARCHITECTURE

Scalable Routing Architecture

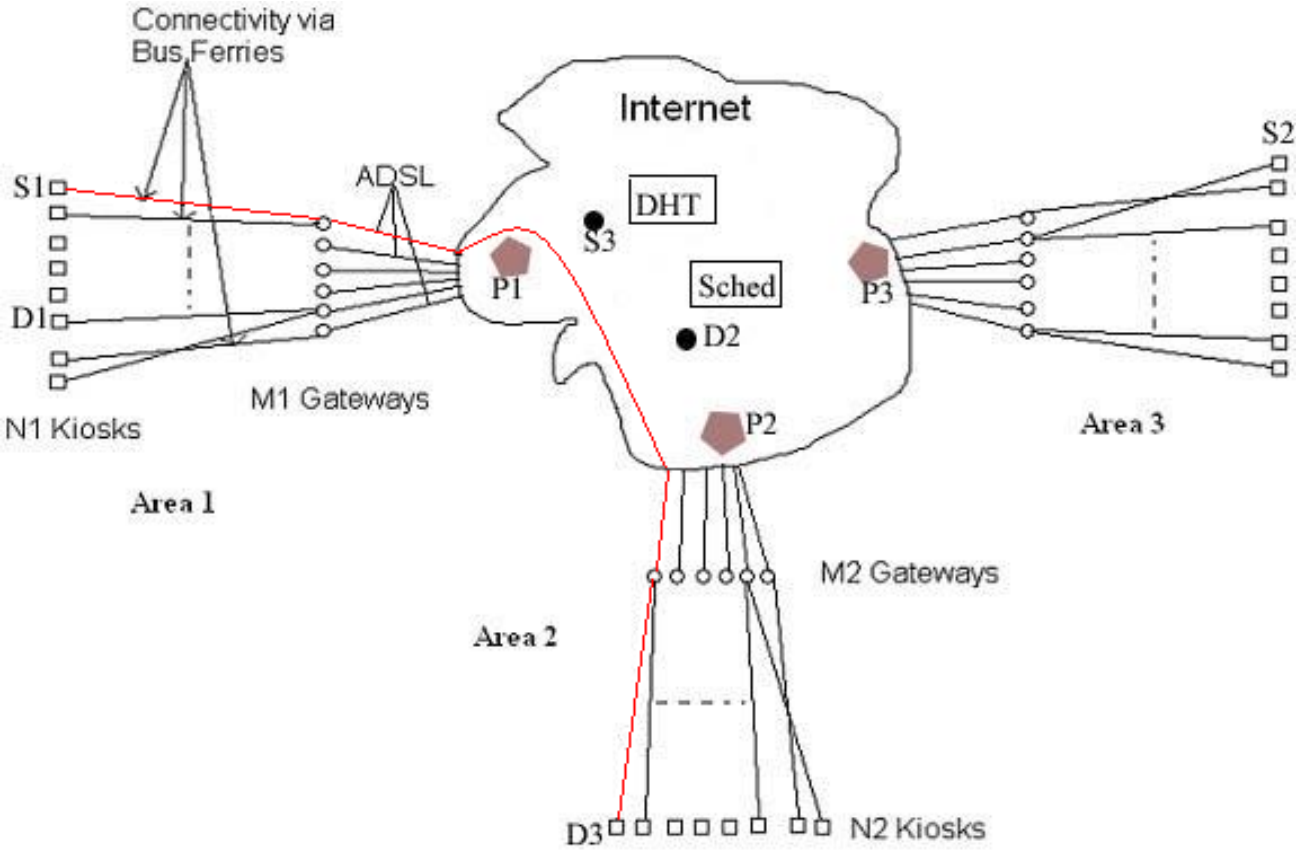


Scalable Routing Architecture

- Intra-Region Routing
  - Flood bundles
    - Redundancy = Robustness
    - No book keeping requirement
    - Bundle received over best path
    - Delivery to multiple gateways for inter-region routing
  - Smart Flooding
    - Metadata exchange
    - Death Certificates

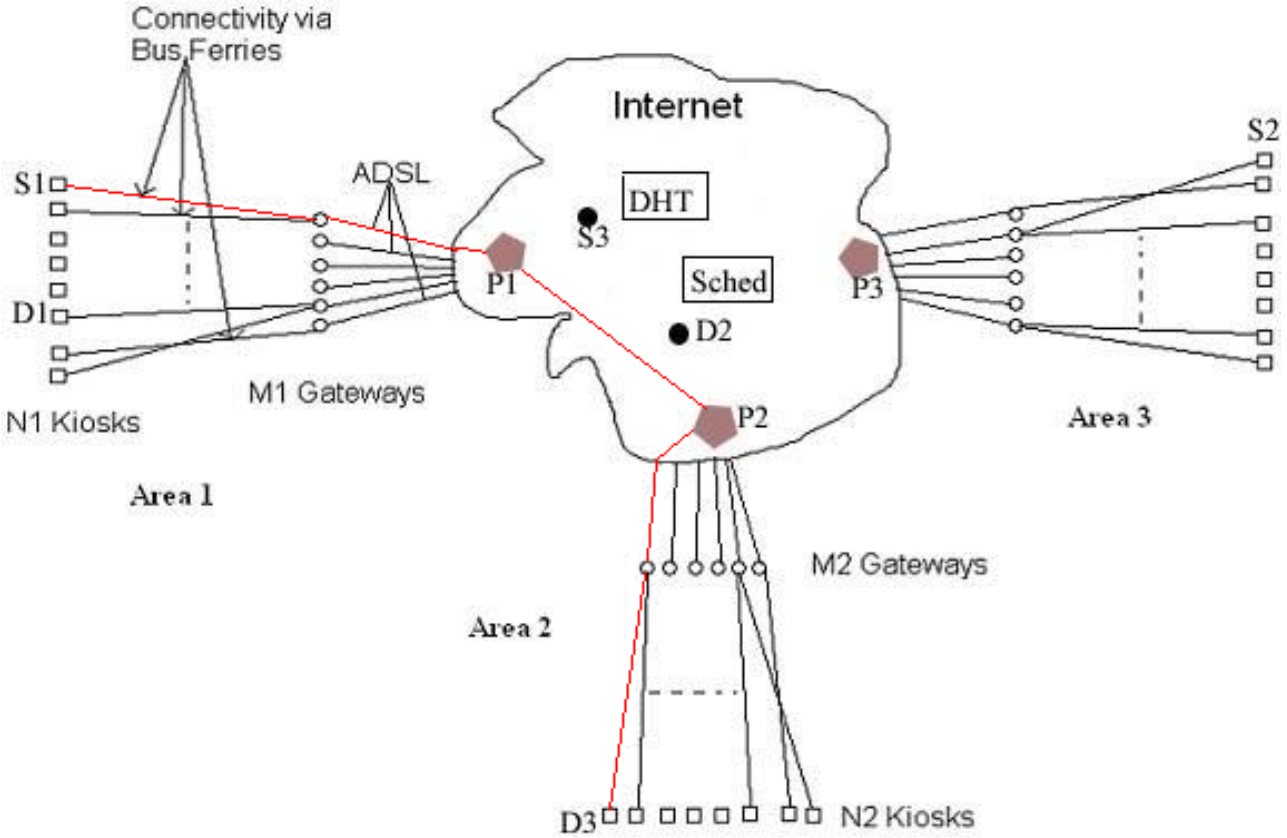
Scalable Routing Architecture

- Inter-Region Routing: G2G



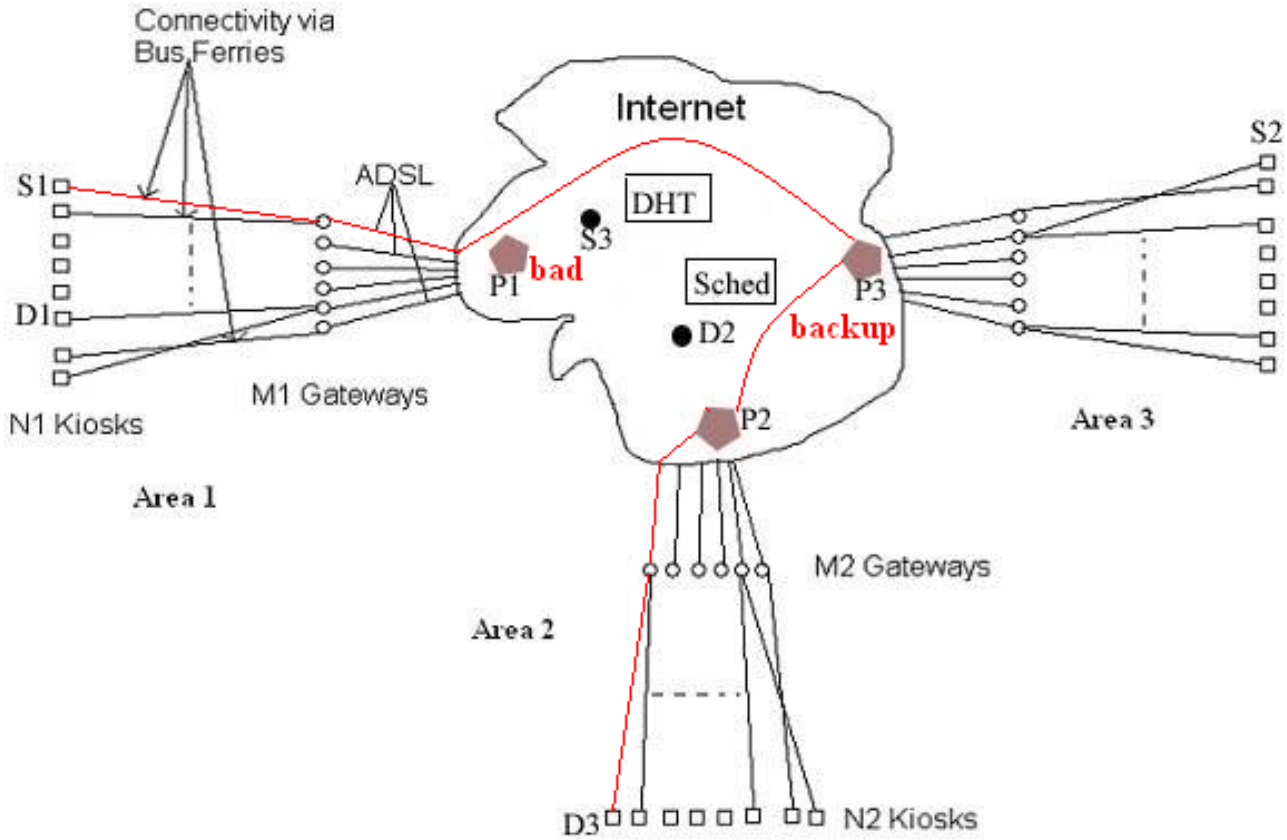
Scalable Routing Architecture

- Inter-Region Routing: G2P



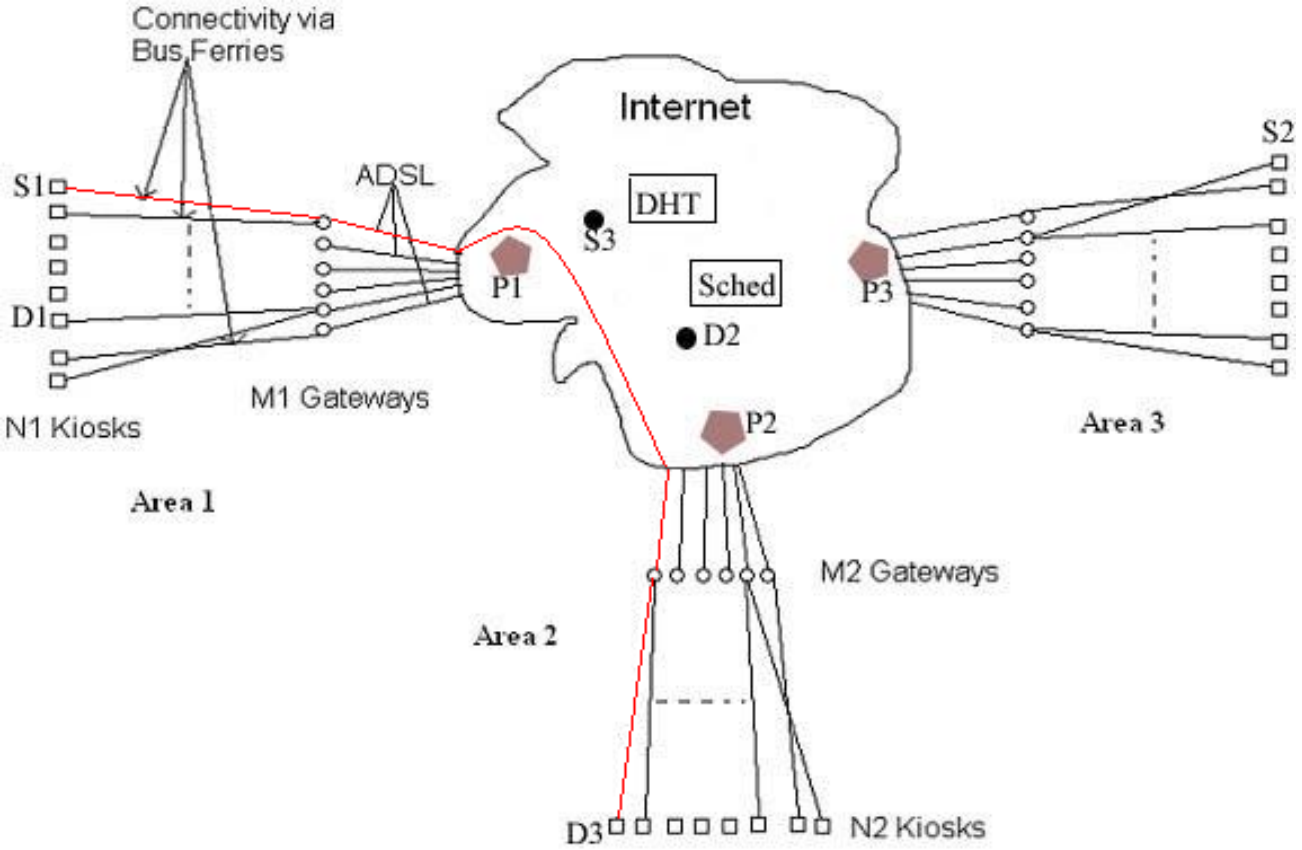
Scalable Routing Architecture

- Inter-Region Routing: G2PB



Scalable Routing Architecture

- Inter-Region Routing: G2GC



Scalable Routing Architecture

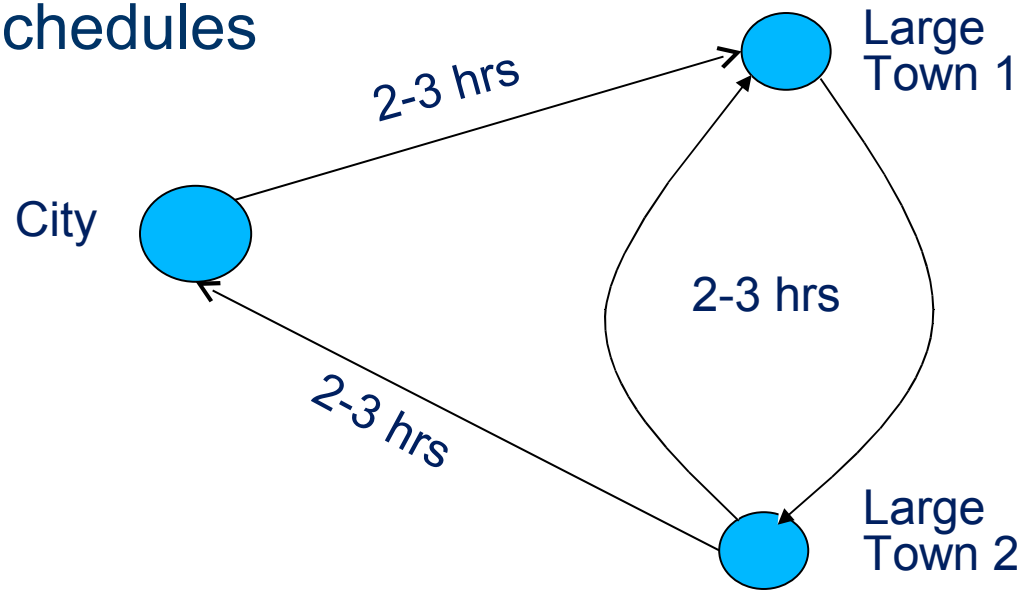
- Comparison of various inter-region routing approaches:

Solutions	Performance	Reliability	Complexity
G2G	High	High	High
G2P	Low	Low	Low
G2PB	Low	High	Medium
G2GC	Low	High	Medium

EVALUATION

Evaluation: Intra-Region Routing

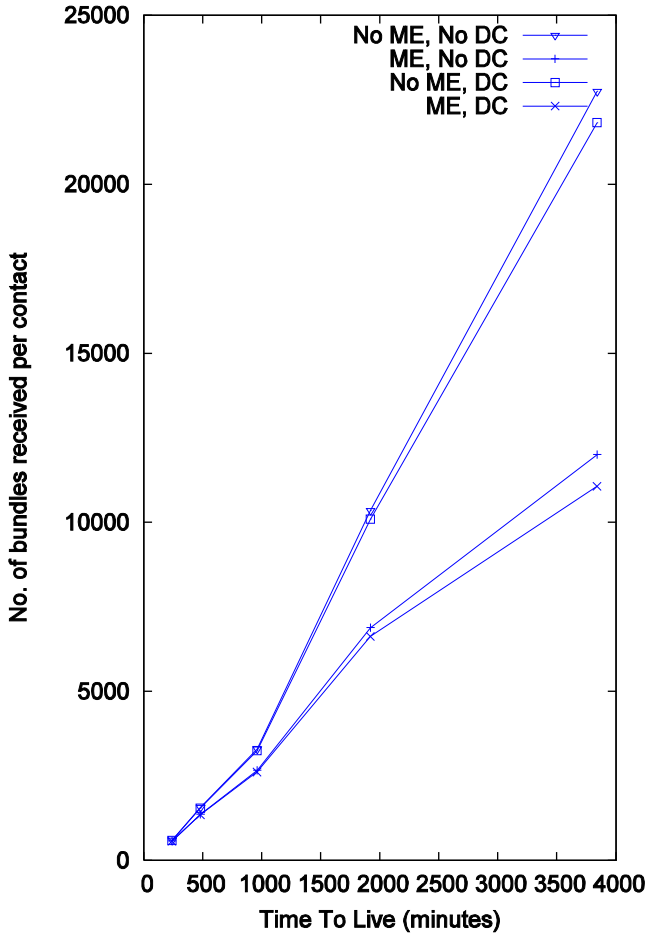
- Simulation setup
  - 100,00 nodes
  - 100 nodes per region: 80 kiosks, 10 buses, and 10 gateways
  - Bus Schedules

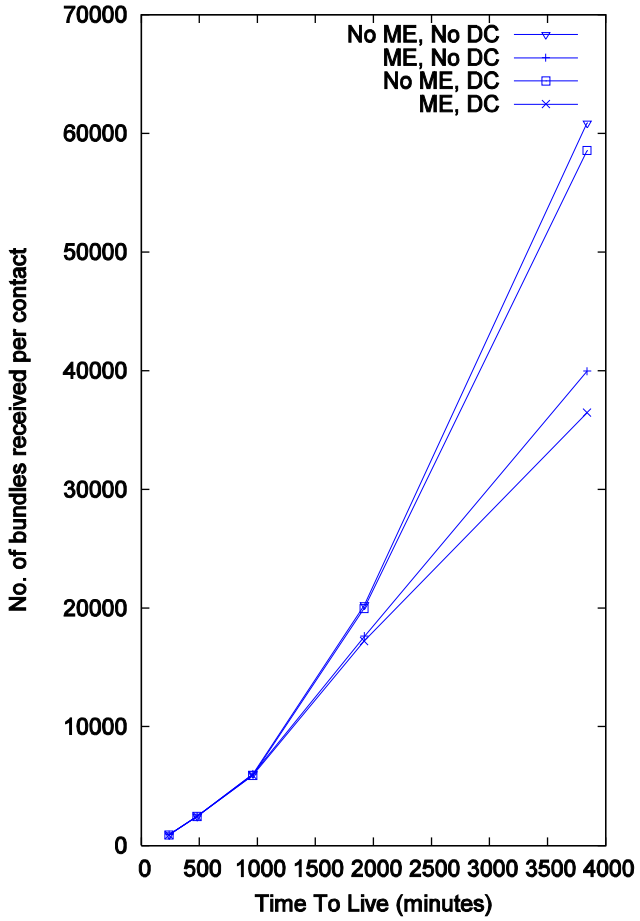


Evaluation: Intra-Region Routing

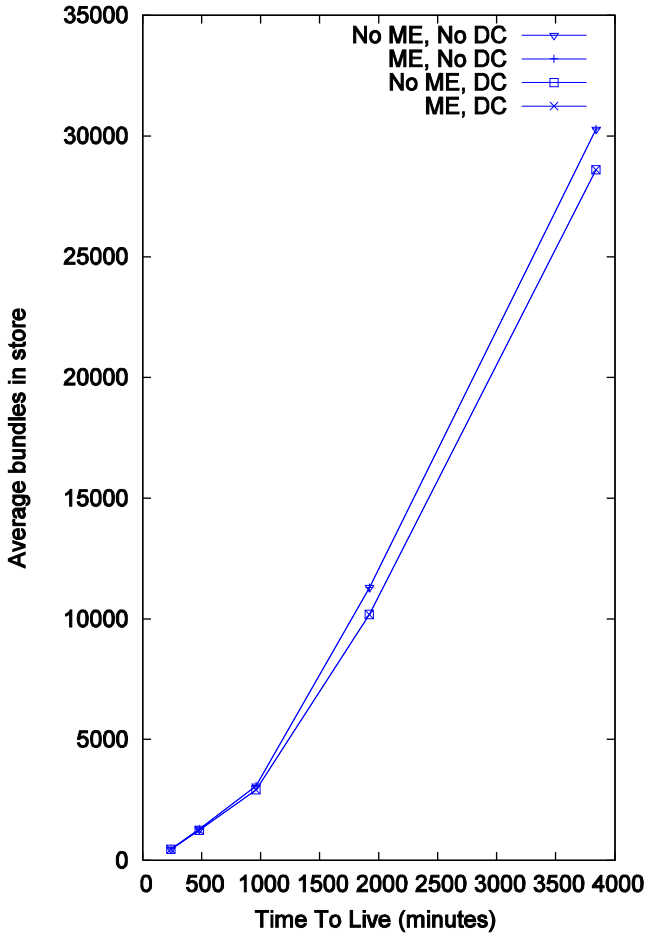
- Simulation setup continued
  - Tuning parameters
    - Bundle generation rate 1 bundle/minute/node and 0.5 bundles/minute/node
    - Bundle TTL values of 240, 480, 960, 19200 and 3840 minutes.
    - NoME-NoDC, NoME-DC, Me-NoDC and ME-DC
  - Measured metrics
    - Average and maximum number of bundles in store at a node at any point of time during the simulation
    - Average and maximum number of bundles received by a node per contact during the simulation.

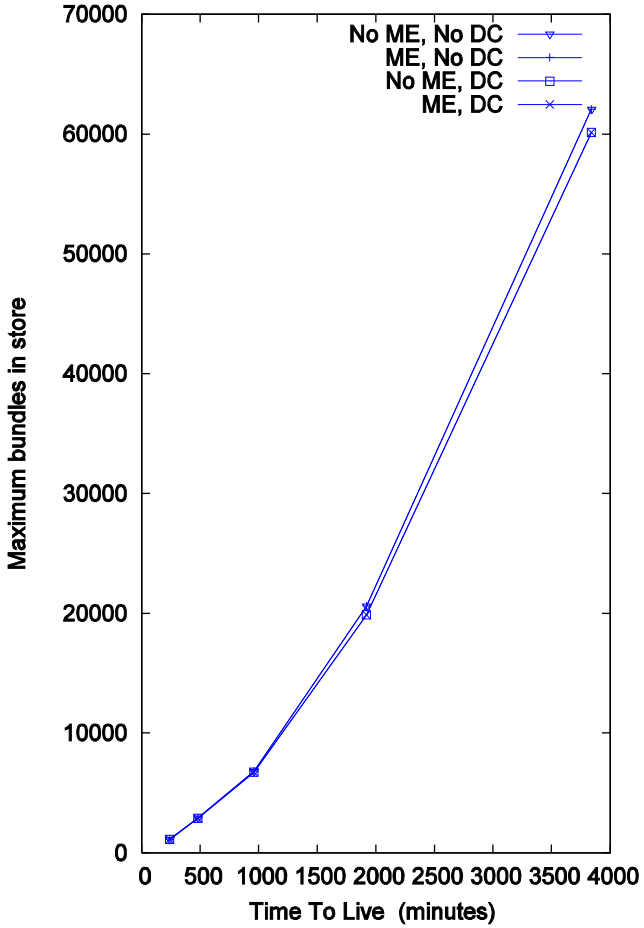
Evaluation: Intra-Region Routing





Evaluation: Intra-Region Routing





Evaluation: Intra-Region Routing

- Potential Bottlenecks
  - Nonvolatile storage
  - Network Bandwidth
  - CPU capacity

- Nonvolatile storage
  - Maximum bundles in store = 62,000
  - Assuming 50KB bundle size 62K ⇔ 3.1GB << 40GB
  - Storage NOT a bottleneck

Evaluation: Intra-Region Routing

- Network Bandwidth
  - Assuming nominal application throughput of 10Mbps, 75MB of data can be transferred per minute.
  - For TTL value of 960, bundle generation rate of 1bundle/min/node, and for ME-DC average number of bundles exchanged per contact = 5000
  - This implies avg bundle size = 75K/5K = 15KB
  - This translates to 21.6MB/day/node or 650MB/month/node

Evaluation: Intra-Region Routing

- CPU capacity
  - Poor application throughput achieved.
  - In theory 802.11g is 5 times faster than 802.11b but not even 2 the throughput was achieved
  - CPU capacity is a major bottleneck
  - Allows 260MB/month/node

802.11 Type	20MB	25MB	30MB
b	53.58	67.40	81.70
g	42.78	54.41	66.34

Evaluation: Inter-Region Routing

- Using same numbers as the simulation
  - Bundle generation rate 1bundle/min/node
  - 100 nodes per region
- Analysis for G2P and G2PB
  - Total 100,000 bundles/minute in the system
  - Assuming equal division to all the regions 100 bundles/region/minute to be processed by the proxy.
  - This translates to 1.66 bundles/second.
  - Proxy lies on the data path.

Evaluation: Inter-Region Routing

- Analysis for G2GC
  - Total 100,000 bundles/minute in the system
  - This implies that at centralized scheduler must process 100,000req/minute = 1,666 req/sec.
- Analysis for random gateway selection
  - Simulation setup
    - Region 100 nodes
    - 100 bundles/min to the region, ideally 10 per gateway
    - Overload variable for each gateway
    - Simulation run for 60 hours ⇔ 360,000 bundles
    - 10 runs of the simulation
  - Maximum overload of 564 bundles ⇔ 27Mb ⇔ 4.5 minutes

Future Work

- Implementation of G2P and G2PB
- Stress testing of the implementation
- Deployment and study of traffic loads

Conclusion

- Successfully designed, implemented and evaluated a scalable and robust routing protocol for mechanical backhaul networks
- Smart flooding is a good design choice
- Identified CPU capacity as the primary bottleneck for the system
- The system can allow upload of up to 260MB/node/month

Thank You