Empowering Internet-tv-based e-learning in rural villages with delay tolerant connectivity:

Using frequent visitors as message ferries

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Rural areas in thailand

Some schools are difficult to access by car in Kanchanaburi,

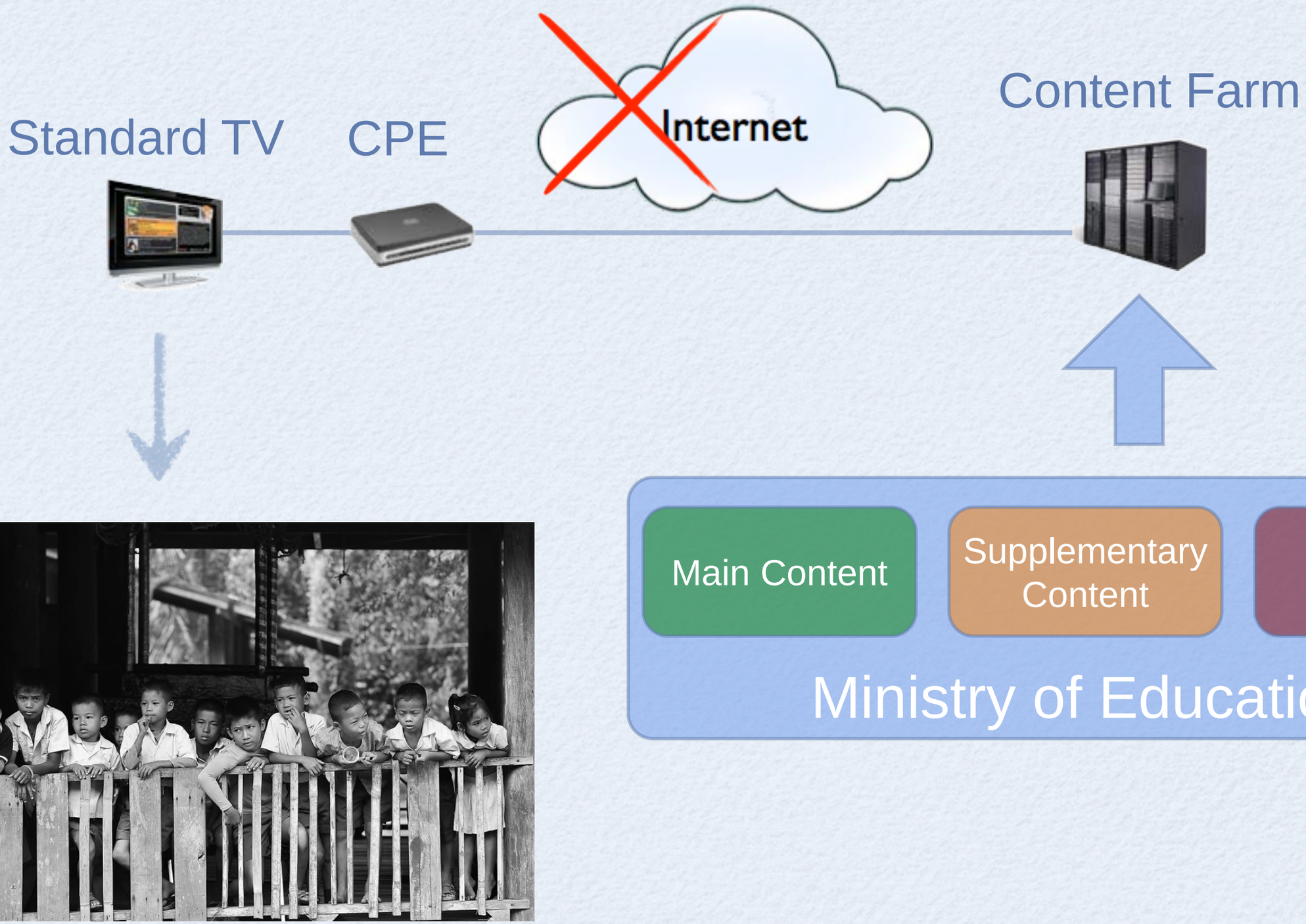
Picture Credit: vistaimage.net

Rural areas in thailand

- Tele-Centers and viability
  - Donation of equipment ➠ One time
  - Setting up the Internet ➠ Running cost
- Local villagers have no intention to pay for monthly Internet fee
- Telecenters become a burden, not a facility

Picture Credit: vistaimage.net

e-learning through ip-tv



Delay/Disruption tolerant network

- Intermittent/Unreliable Connectivity
- Expensive data transmission cost
- Extremely long delay is acceptable
  - Realtime ➠ Non-realtime ➠ DTN
  - Examples?

E-learning in rural areas and DTN

DTN Characteristics	Rural Areas
- Intermittent/Unreliable Connectivity - Expensive data transmission cost	The villagers cannot afford to pay for monthly Internet fee
- Extremely long delay is acceptable	MoE learning contents are not updated very frequently

Inter-planetary network (IPN)

- Intermittent connectivity

Earth station

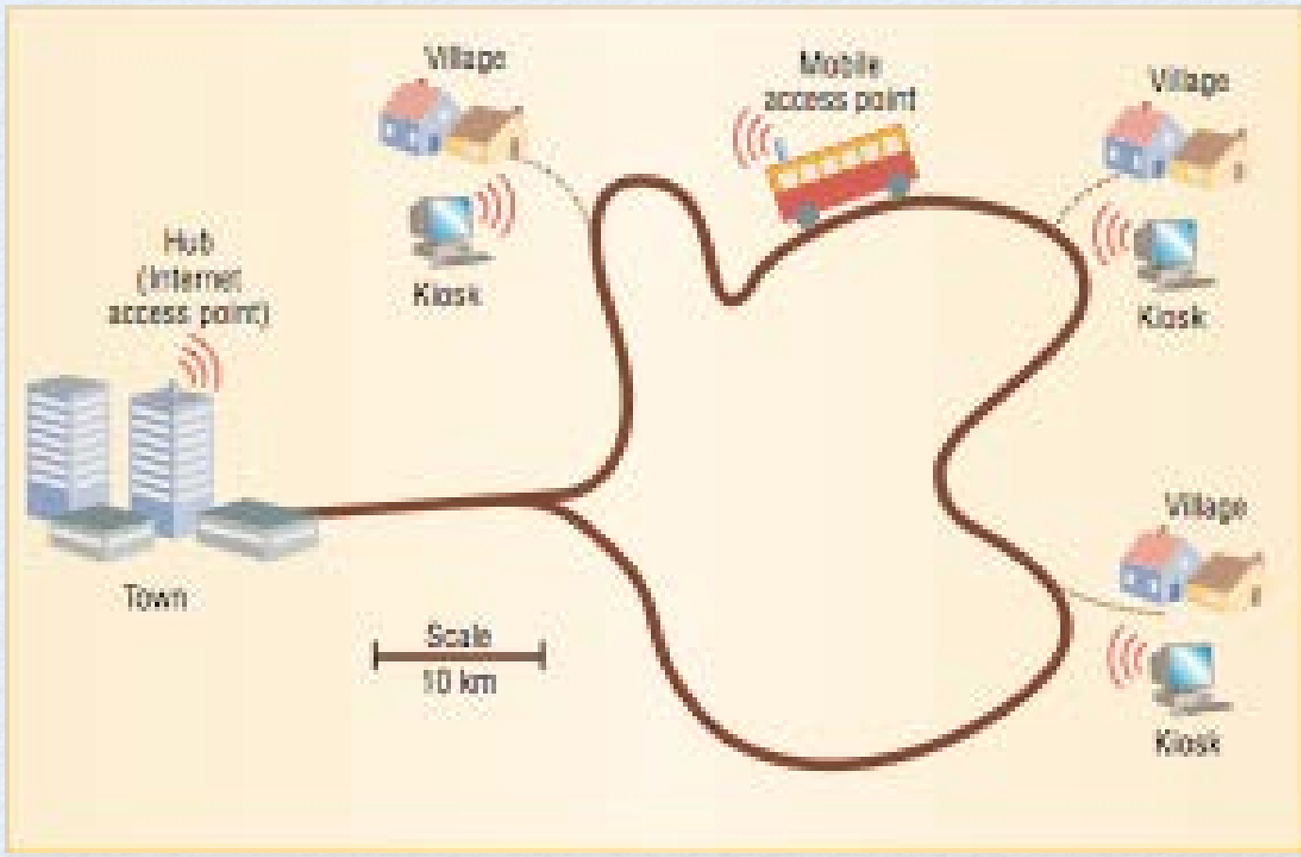
Orbital Satellite

Remote Communicator

- Bandwidth is expensive, but the delay is tolerable
- Store and forward
- Multi-hop: Electronic & Physical

ICT Development in rural areas

- DAKNET
- Installation of Kiosks in the rural areas
- Use buses equipped with mobile access points to carry info. to the city.
- Example info.
  - Public Land Records
  - Emails
  - Etc.



DTN and e-Learning

- The local village is quite hard to reach
- But there will be frequently visitors (e.g., traveling postmen)
- Use the visitors as message ferries

DTN and e-Learning

Rural areas

Main Content

Supplementary Content

Activities

Well connected cities

key questions

- How well will the DTN perform?
- Throughput = ?
- What are the key factors, which affect the throughput? How much effect they have on throughput?

Modeling the mailman

- The mailman travels with a content delivery device

  - Mass storage
  - Wifi Transceiver
  - Automatic transfer

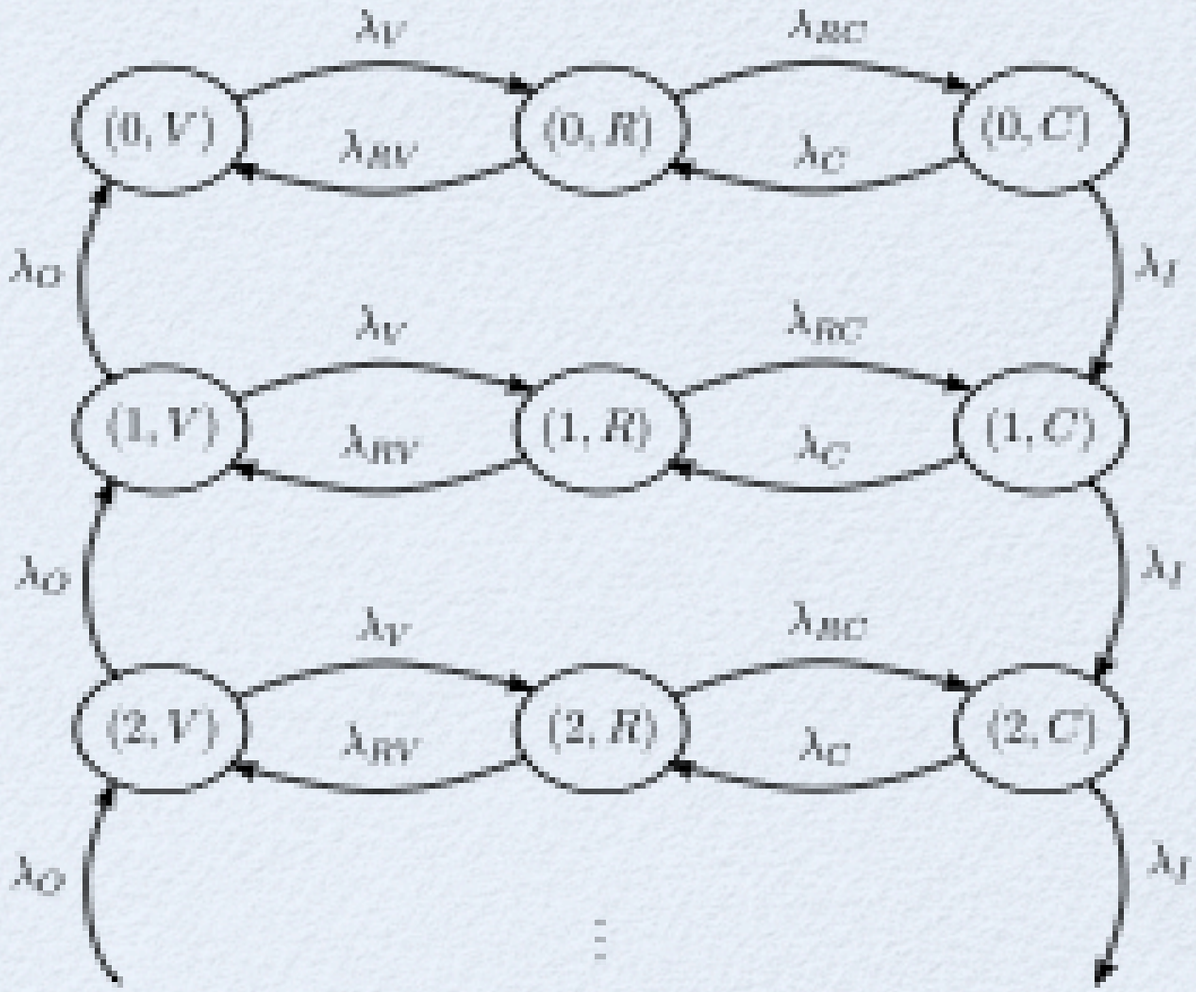
- Everyday, the mailman delivers letters and packages from the city to the rural village.
- The mailman returns to the city everyday.

Modeling the mailman

- At the city:
  - The device downloads new learning contents
  - New contents are created according to Poisson distribution
  - The mailman stays in the city (downloadable area) with a random amount of time
- On the route: The mailman spends a random amount of time traveling between the city and the village
- At the village:
  - The device automatically upload the content to the local station
  - The upload time for one byte is exponentially distributed
  - The mailman spend a random amount of time traveling from the village to the city

Modeling the mailman

- Two dimensional Markov Chain
  - Dim-1: Location = {C(ity),(on the)R(oute),V(illage) }
  - Dim-2: Buffer size in bytes



Two key questions

- What's the condition where the queue does not grow to infinity

$$\frac{\lambda_{RC}}{\lambda_R}\lambda_I\frac{1}{\lambda_C} < \frac{\lambda_{RV}}{\lambda_R}\lambda_O\frac{1}{\lambda_V}.$$

- What is the throughput

$$T = \lambda_I \left(\frac{\frac{\lambda_{RC}}{\lambda_R}\frac{1}{\lambda_C}}{\frac{1}{\lambda_R} + \frac{\lambda_{RX}}{\lambda_R}\frac{1}{\lambda_V} + \frac{\lambda_{RC}}{\lambda_R}\frac{1}{\lambda_C}} \right)$$

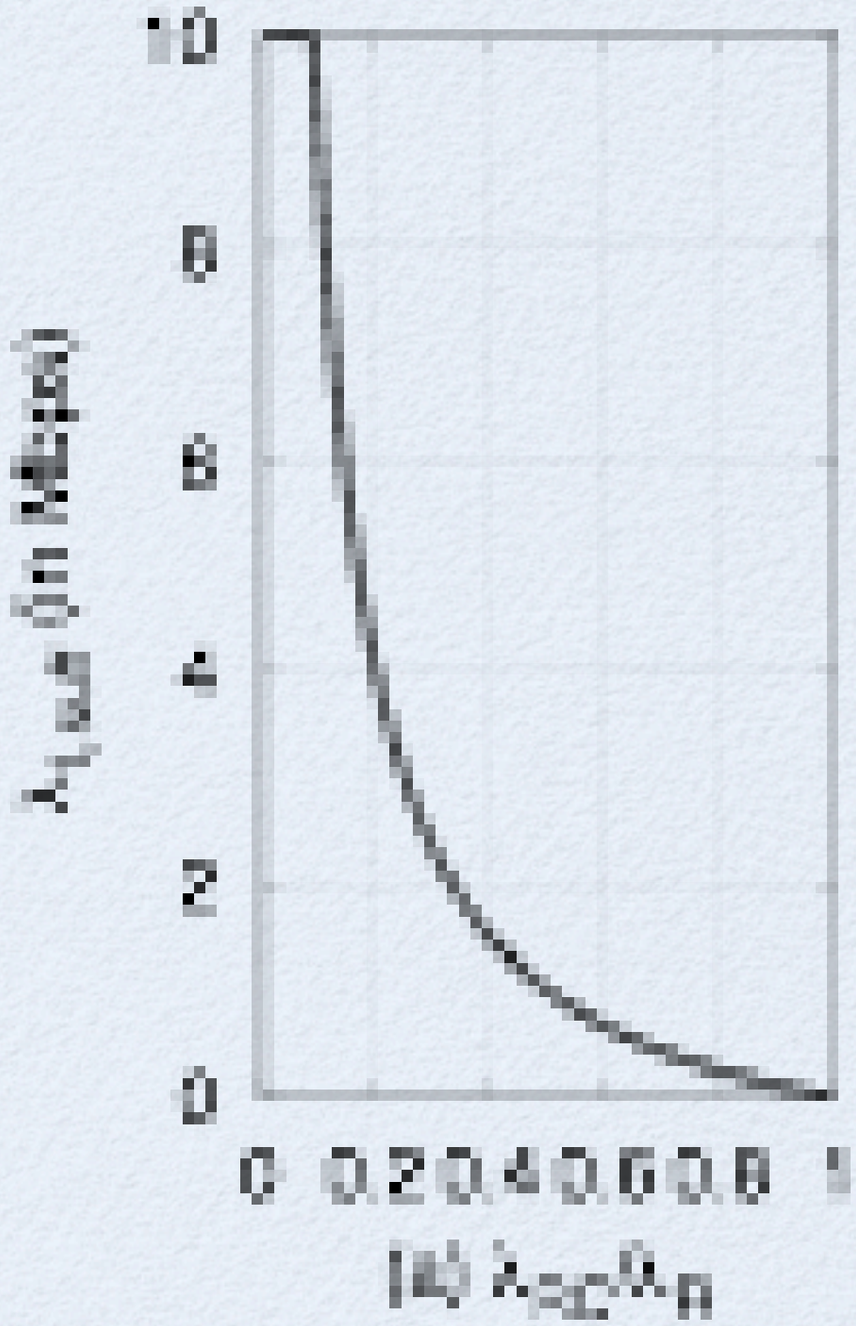
Experiment setup

CASE-STUDY SCENARIOS

Parameter	Scenario A	Scenario B
λ_f (in Mbps)	≤ 10	≤ 10
λ_{CI} (in Mbps)	1	1
λ_V (in 1/hr)	1/6	–
λ_C (in 1/hr)	1/6	–
λ_{RV} (in 1/hr)	–	1/36
λ_{RC} (in 1/hr)	–	1/36
λ_R (in 1/hr)	1/18	–
$1/\lambda_C + 1/\lambda_V$ (in hr)	–	6
λ_{RC}/λ_R	0.01-0.99	–
λ_V/λ_C	–	0.01-0.99

numerical result

- Max. input rate under which the system still sustain
- Visiting the city ↑
  ➠ No need to download a lot at a time



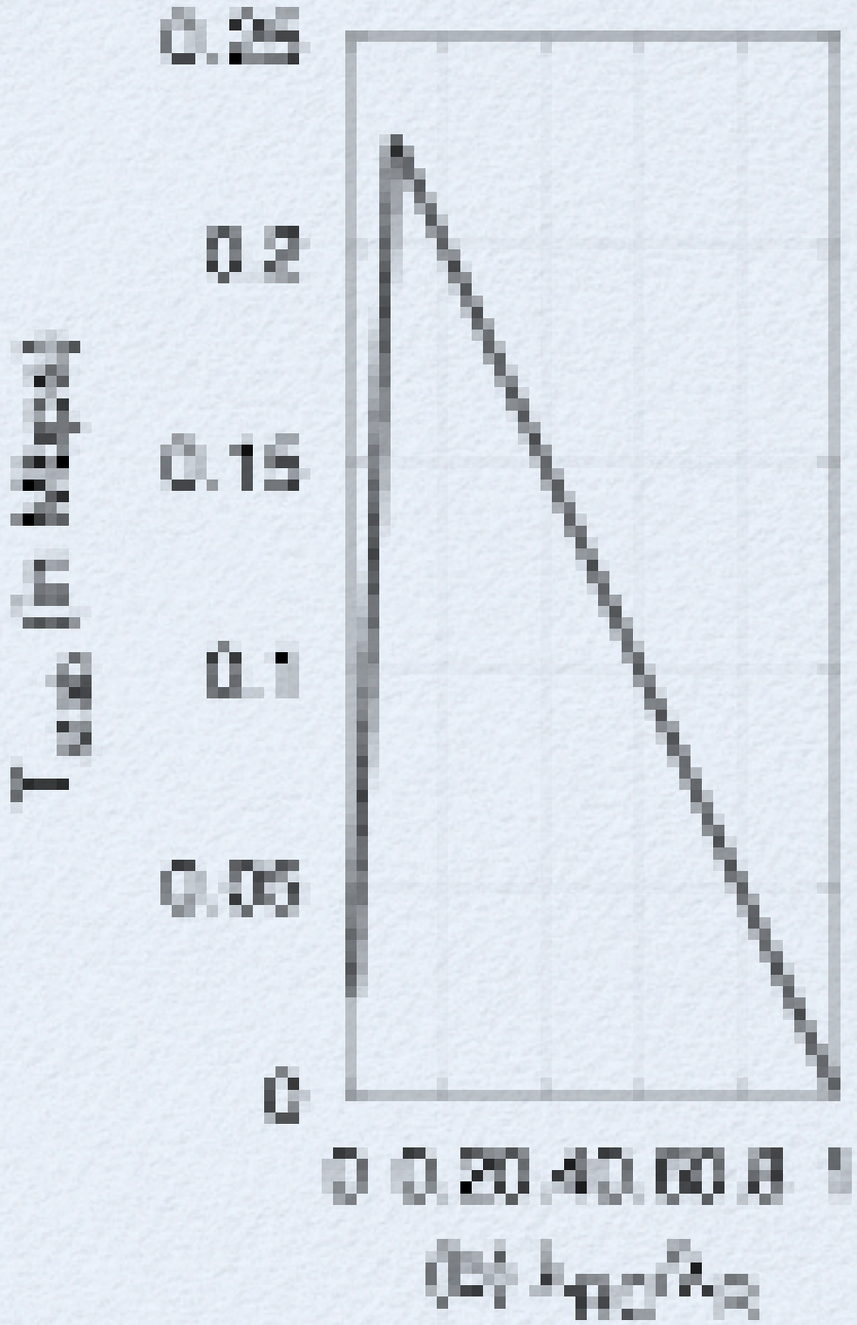
Experiment setup

- Infinite buffer size:

$$T = \lambda_I \sum_{k=0}^{\infty} p_{k,C} = \lambda_O \sum_{k=1}^{\infty} p_{k,V}$$

$$= \frac{\lambda_I \lambda_V \lambda_{RC}}{\lambda_V \lambda_C + \lambda_C \lambda_{RV} + \lambda_V \lambda_{RC}}$$

- Max. throughput is achieve for moderate value of λ_{RC}



Summary

- Developing country
- Intermittent connectivity
- Inability to afford Internet monthly fee
- Delay Tolerant Network: Using mailmen as message ferries
- Mathematic modeling
- Increasing data rate in the city does not necessarily be beneficial

thank you for your attention