USING NETWORK ACTIVITY DATA TO MODEL THE UTILIZATION OF A TRUNKED RADIO SYSTEM

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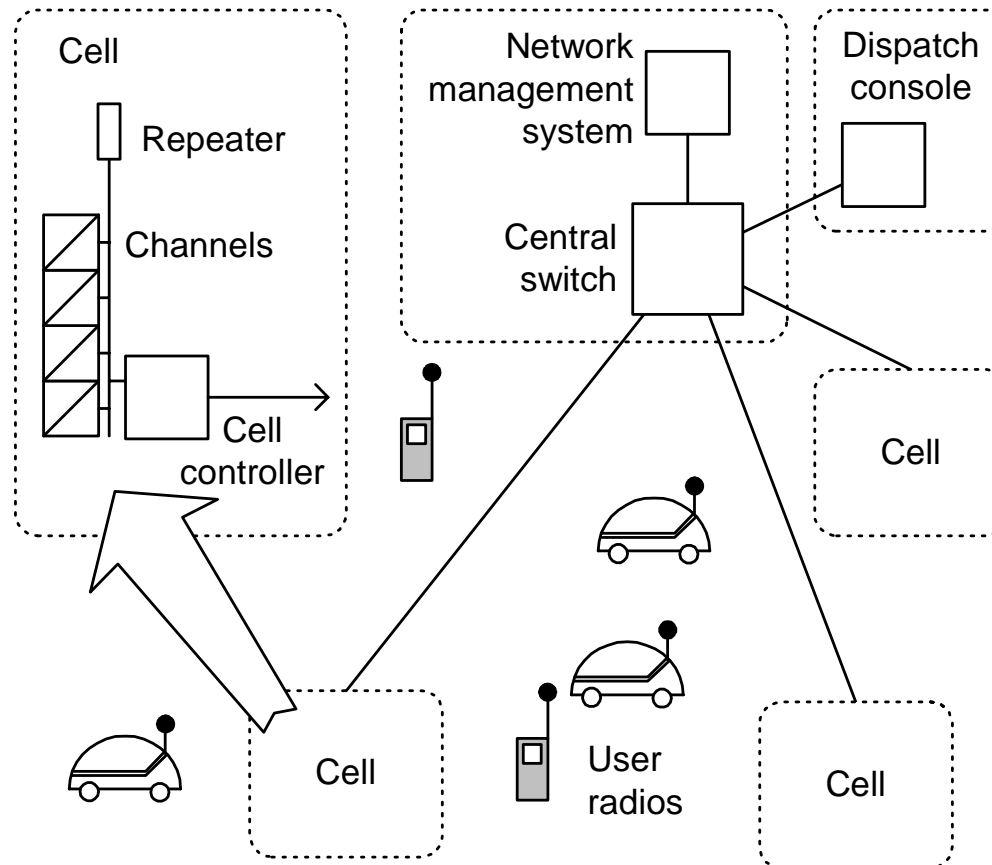
http://www.ensc.sfu.ca/cnl

Simon Fraser University

Road map

- Introduction

- Data and network models

- OPNET simulation results

- Conclusions

Network architecture

Network characteristics

- **Simulcast**: all repeaters covering one cell use identical frequencies

- **Trunking**: all available frequencies in a cell are shared dynamically among all mobile users

- **Cell capacity**: number of available frequencies in a cell

  - one radio channel occupies one frequency
  - one call occupies one radio channel

cell	1	2	3	4	5	6	7	8	9	10	11
channels	12	7	4	5	3	7	6	4	6	6	3

Call establishment

- **Users are organized in talk groups:**
  - one-to-many type of conversations
- **Push-to-talk (PTT) mechanism for network access:**
  - user presses the PTT button
  - system locates other members of the talk group
  - system checks for availability of channels:
    - channel available: call established
    - all channels busy: call queued/dropped
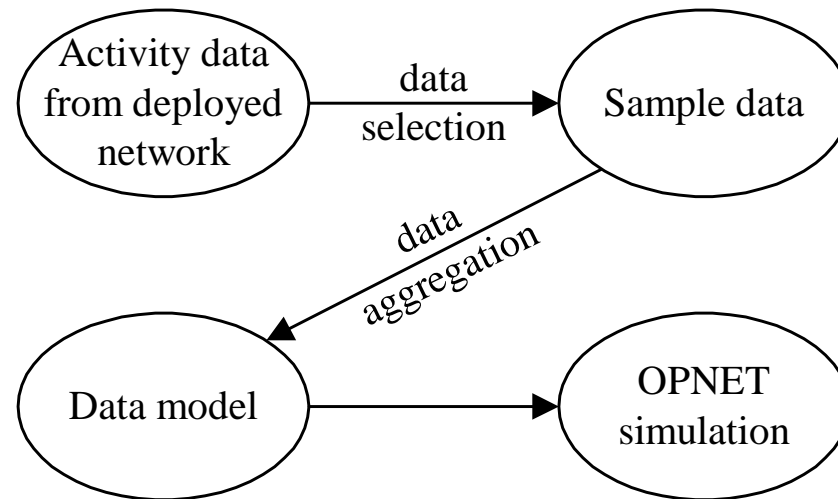 - user releases PTT:
    - call terminates

Data processing

Timestamp	Duration (ms)	Caller	Callee	Cell
2003-03-20 0:00:10.639	4,870	A	B	4
2003-03-20 0:00:10.599	4,830	A	B	8
2003-03-20 0:00:10.529	4,860	A	B	9
2003-03-20 0:00:10.510	4,870	A	B	10

{10.510; 4,870; 4; 8; 9; 10}

Activity data from deployed network → *data selection* → Sample data

Sample data → *data aggregation* → Data model

Data model → OPNET simulation

Data discrepancies (2003)

- Overlapping usage of channels

Timestamp	Duration (ms)	Cell	Channel
2003-03-20 0:00:33.370	9,420	10	4
...	...	...	...
2003-03-20 0:00:42.769	4,290	10	4

- 0:00:42.769 < 0:00:33.370 + 9.420
  - channel 4 in cell 10 is occupied by two calls at the same time!

Network model

- **central switch**

- **11 cells**
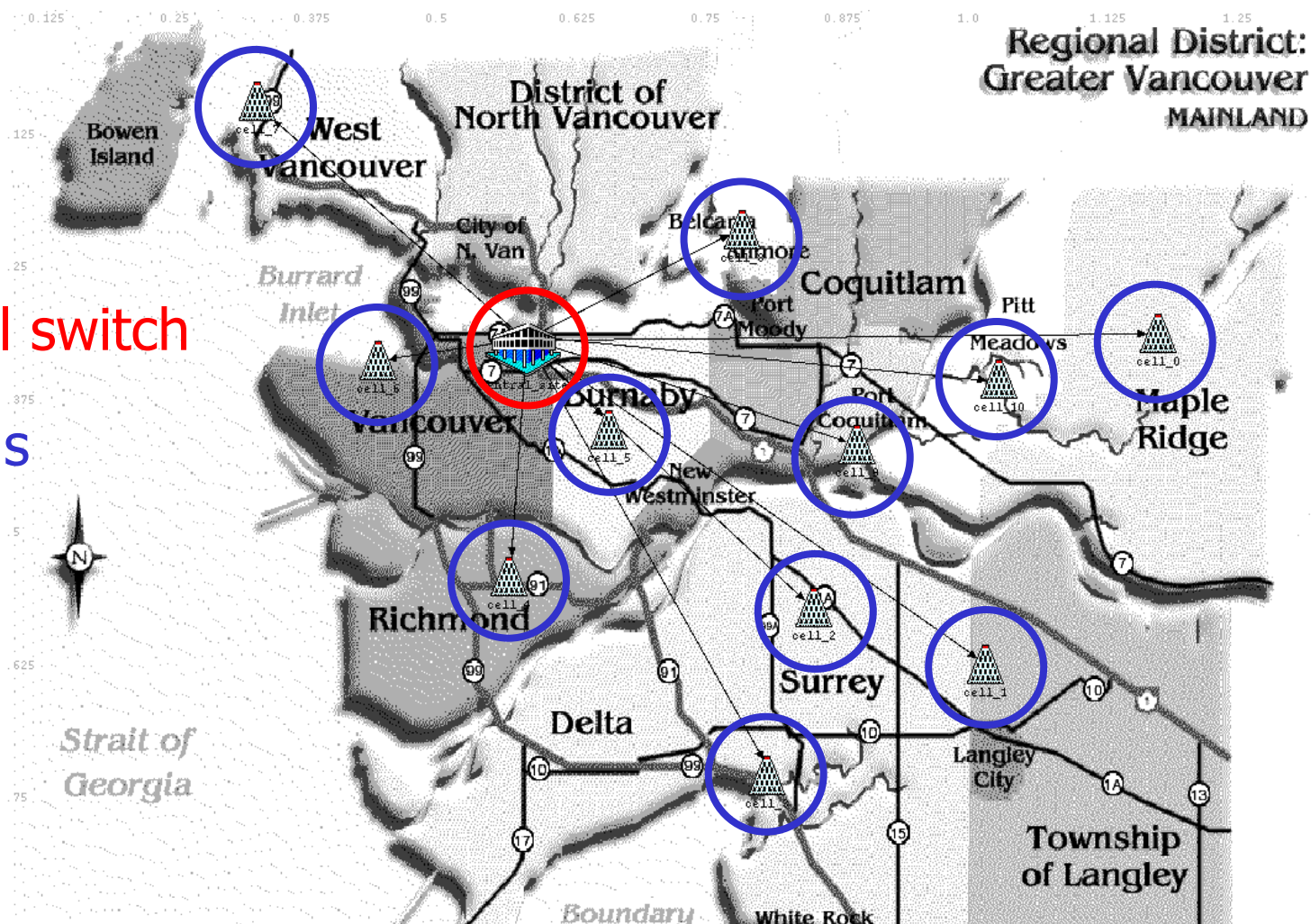
Network model: central switch

- Reads the trace file
- Generates packets according to the trace file
  - one call = one packet
  - packet_size (bits) = $k \times$ call_duration (s)
  - k: bit rate of channels (k=1,000 bps in simulations)
- Checks for availability of channels in the cells
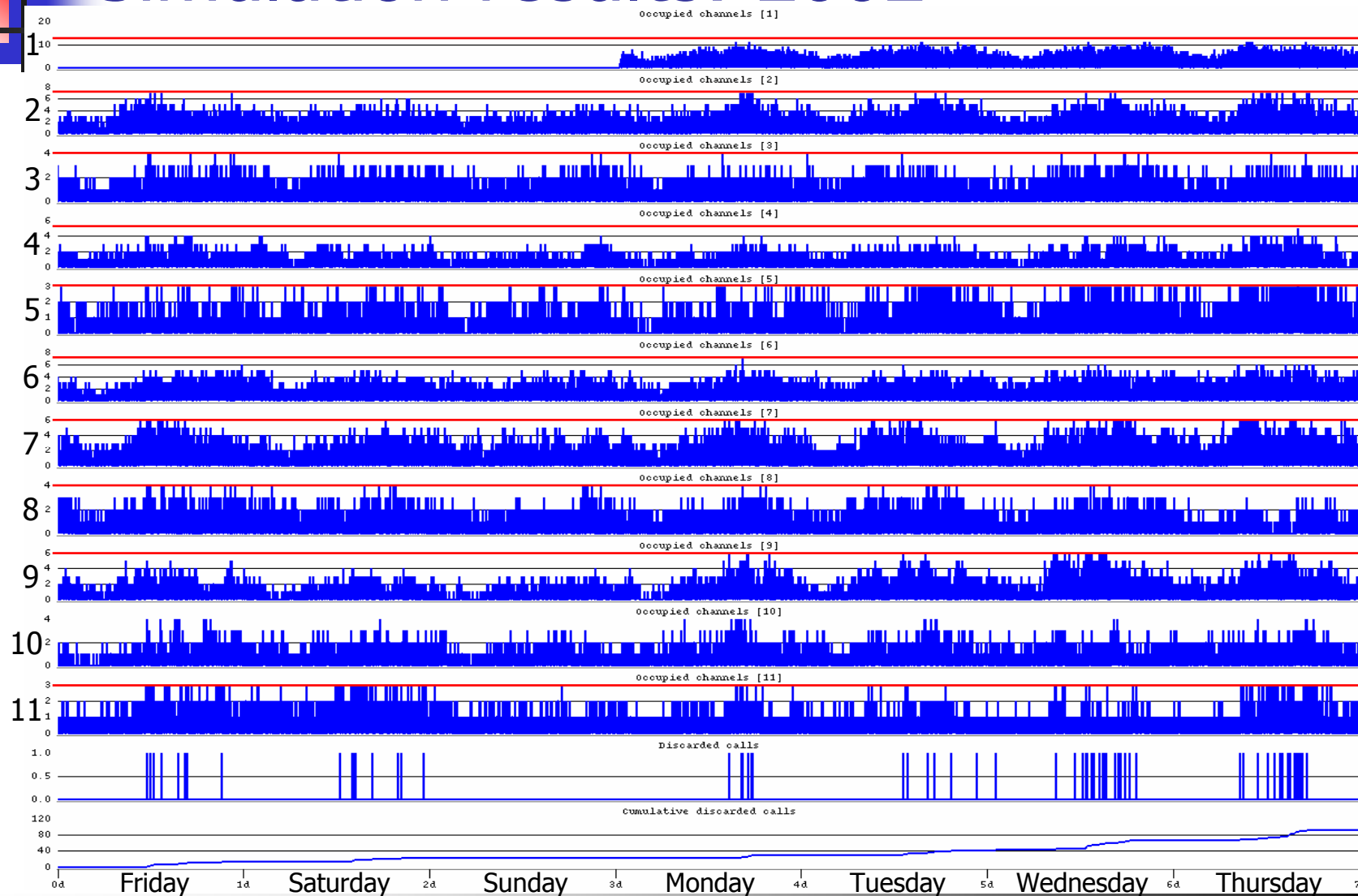- Collects statistics

General statistics

- 2002 sample data:
  - span: 8:00, February 1 – 8:00, February 8
  - number of calls: 403,590
  - discarded calls: 91
- 2003 sample data
  - span: 0:00, March 20 – 24:00, March 26
  - number of calls: 645,167
  - discarded calls: 1,812
- Discarded calls are due to discrepancies in the data
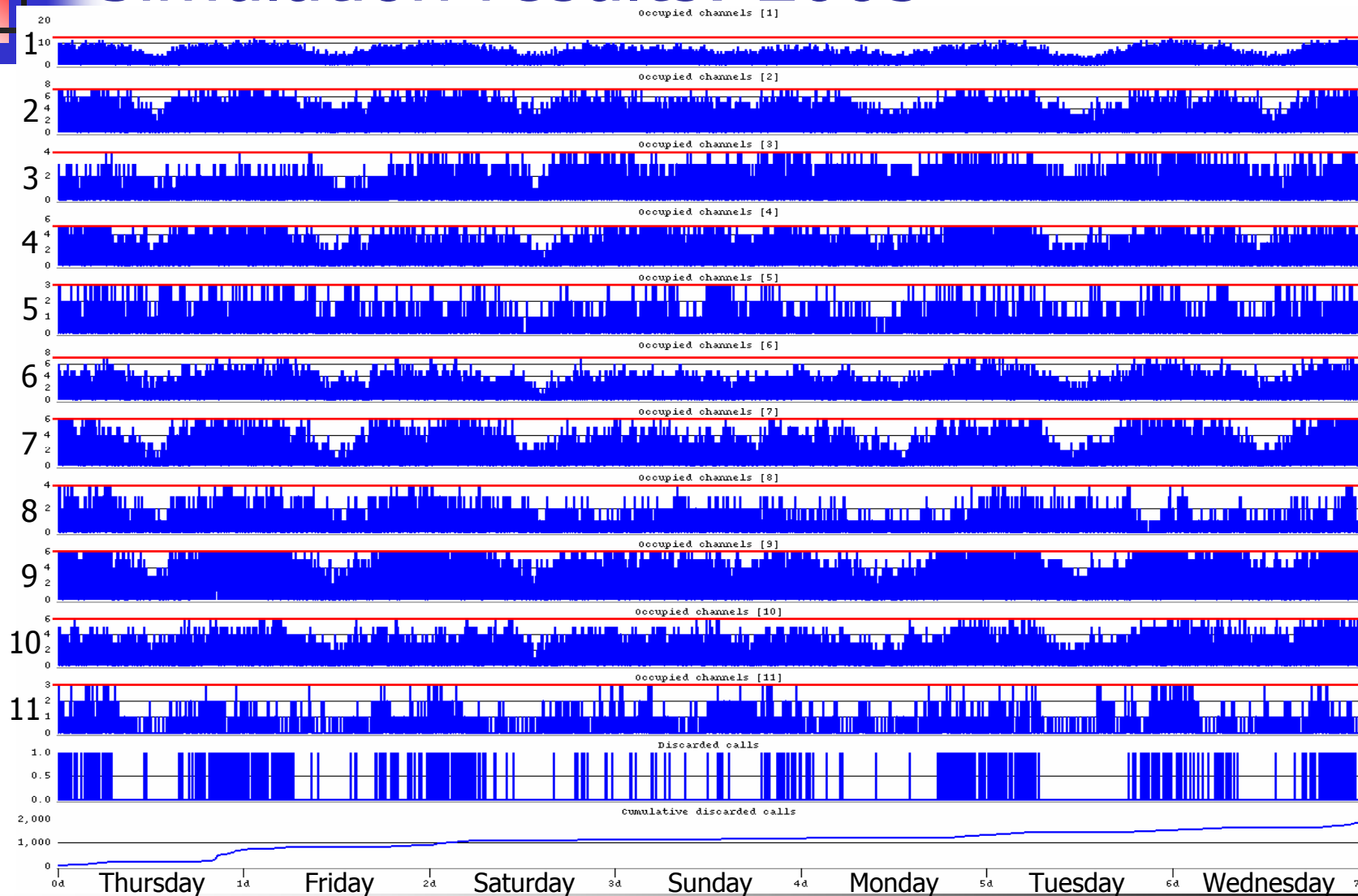 - appear only in simulation results

Simulation results: 2002

Simulation results: 2003

Observations

- **Presence of daily cycles:**
  - minimum utilization: ~ 2 PM
  - maximum utilization: 9 PM - 3 AM
- **2002 sample data:**
  - cell 5 is the busiest
  - others seldom reach their capacities
- **2003 sample data:**
  - several cells (2, 4, 7, and 9) have all channels occupied during busy hours

Discarded calls

- appear only in the OPNET simulation results (do not exist in the deployed network)
- occur during busy hours
- can be used to identify possibly congested cells

Sample data	Cell no.	Capacity	No. of discarded calls
2002		original	91
2002	5	3 + 1	62
2003		original	1,812
2003	9	6 + 1	679
2003	4	5 + 1	521
	9	6 + 1	

original cap.	
cell	ch.
1	12
2	7
3	4
4	5
5	3
6	7
7	6
8	4
9	6
10	6
11	3

Maximum and average utilization

Cell	Capacity	2002		2003	
		Maximum	Average	Maximum	Average
1	12	11	2.5	11	2.6
2	7	7	0.8	7	1.6
3	4	4	0.3	4	0.5
4	5	5	0.3	5	1.1
5	3	3	0.2	3	0.3
6	7	7	0.7	7	1.2
7	6	6	0.7	6	1.1
8	4	4	0.3	4	0.4
9	6	6	0.4	6	1.6
10	6	4	0.2	6	1.0
11	3	3	0.2	3	0.2

Conclusions

- **We created a model in OPNET and simulated two weeks of network activity**

- **Network utilization exhibits daily cycles**

- **Between February 2002 and March 2003:**

    - number of calls increased by ~ 60 %

    - average utilization increased non-uniformly across the network

- **Several cells may become congested in future**

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