From Bullock Carts to Bit Torrents: Robust Networking for the Third World

S. Keshav

Tetherless Computing Lab

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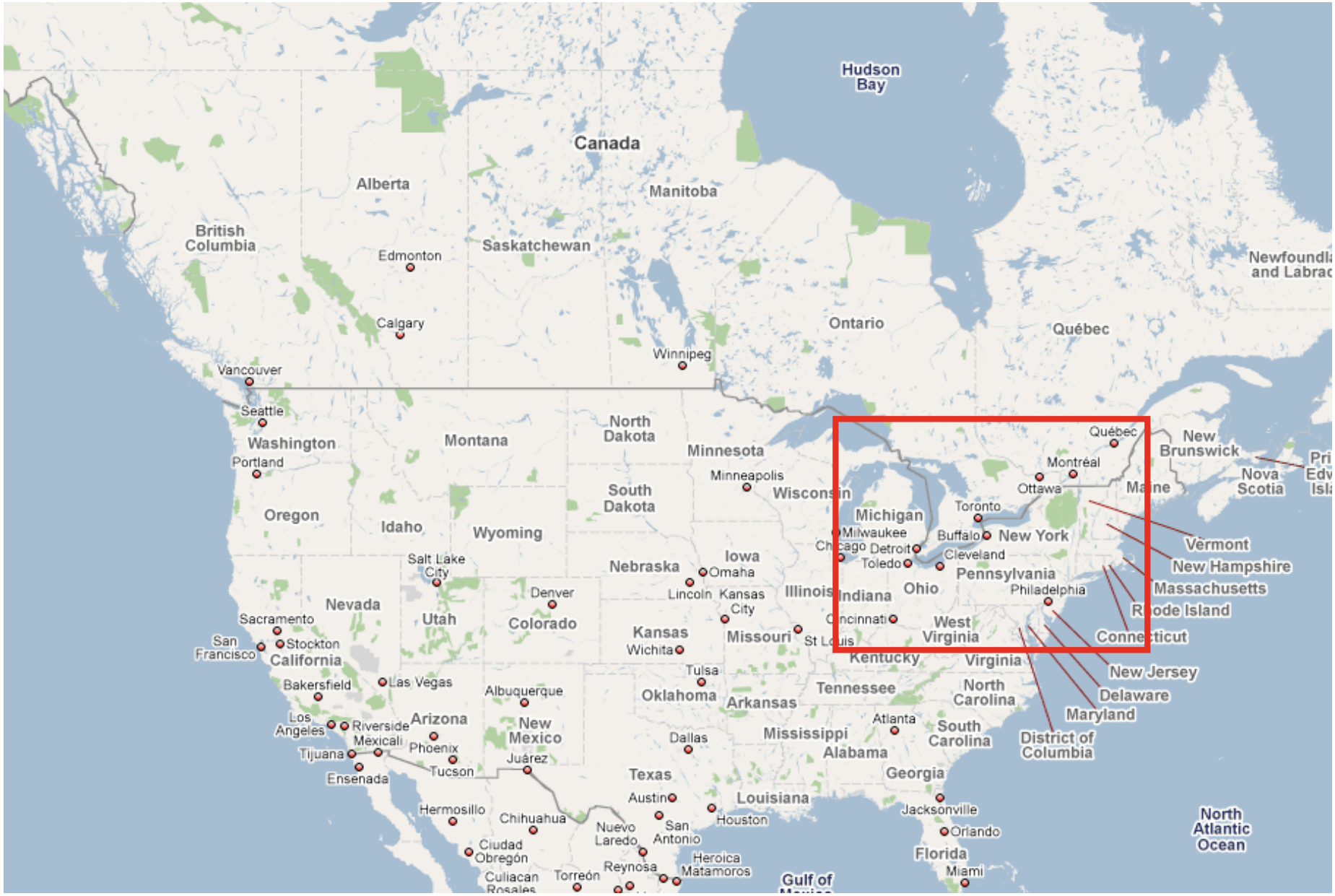
University of Waterloo

September 2009

Waterloo?

Where is that?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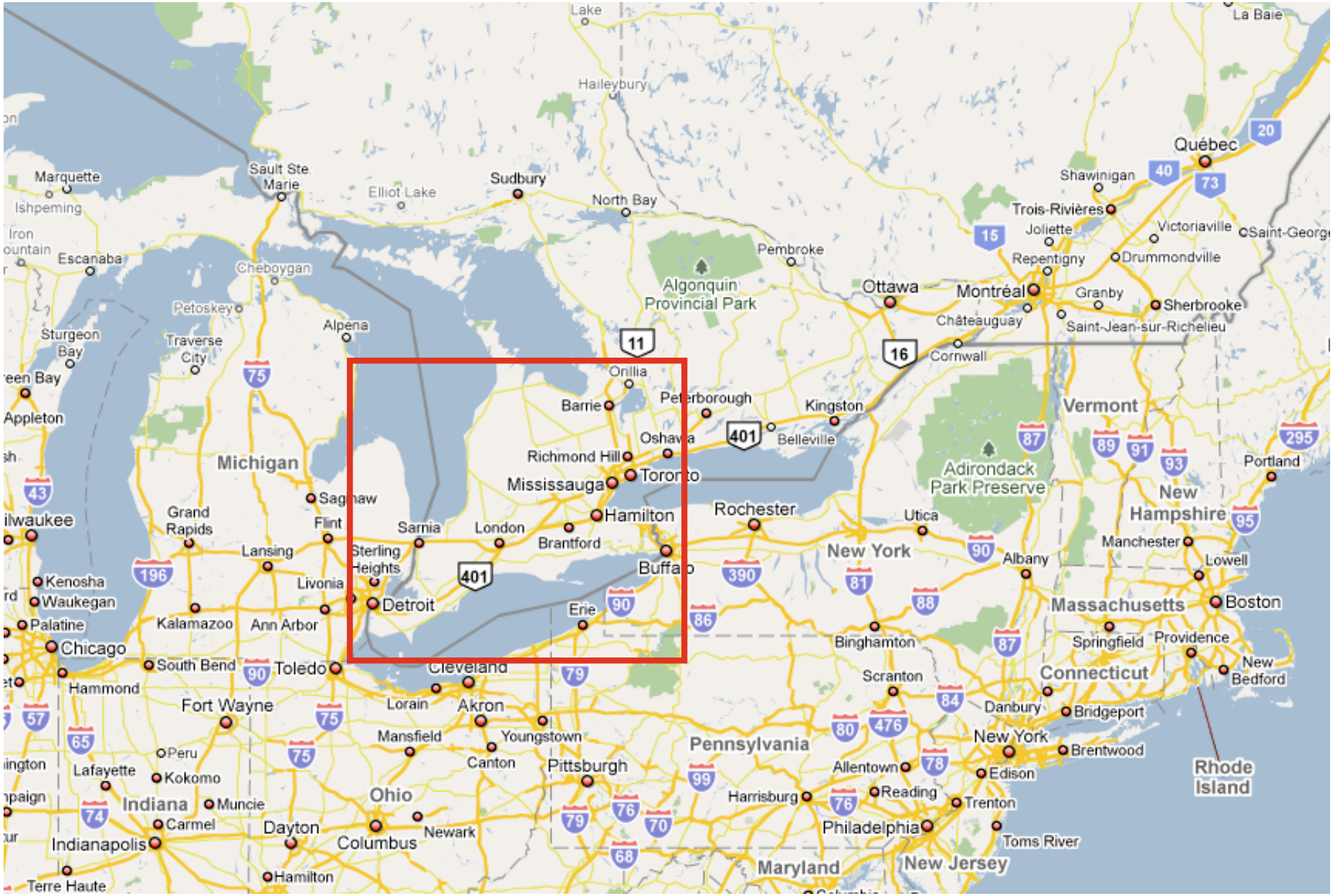
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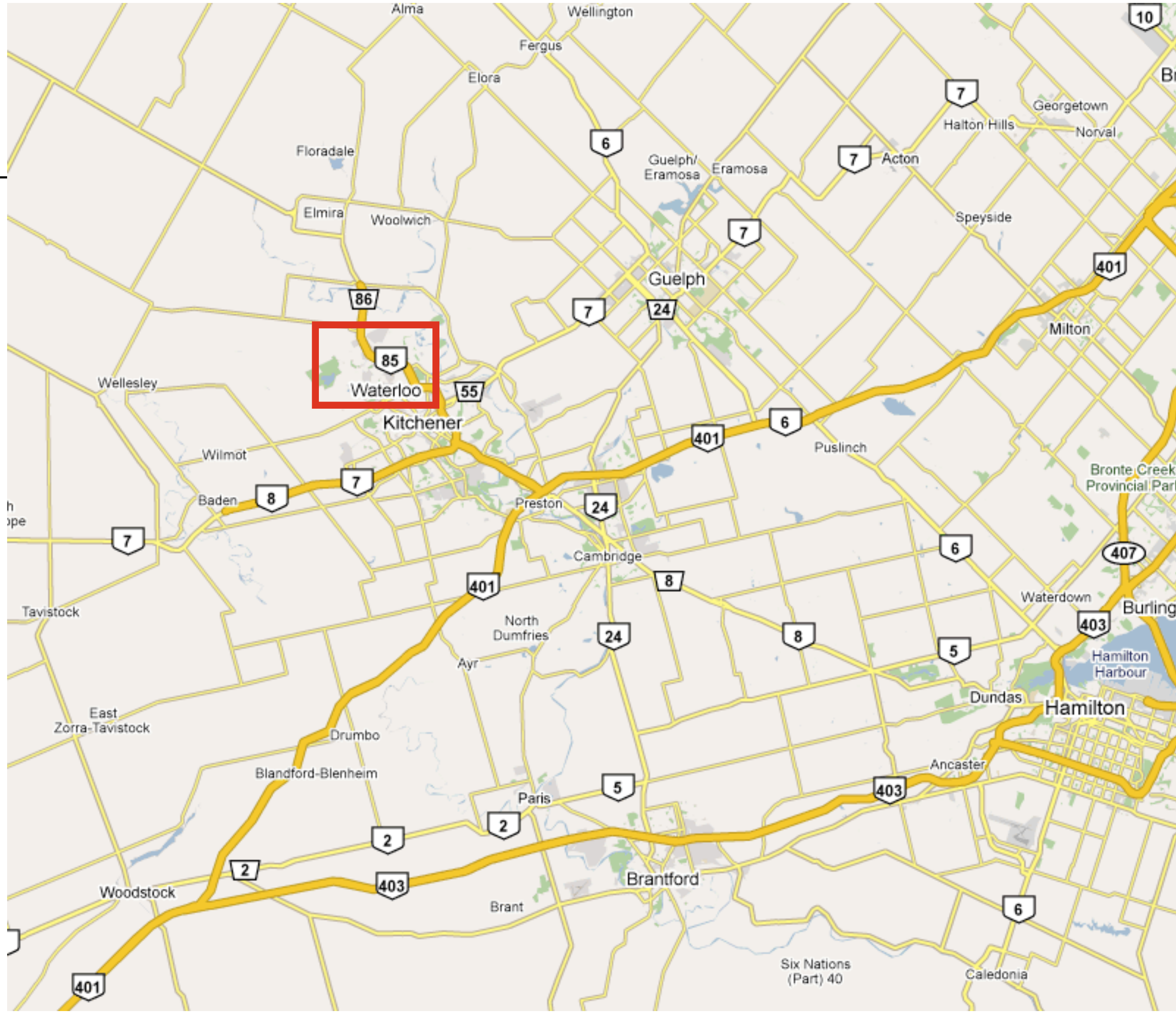
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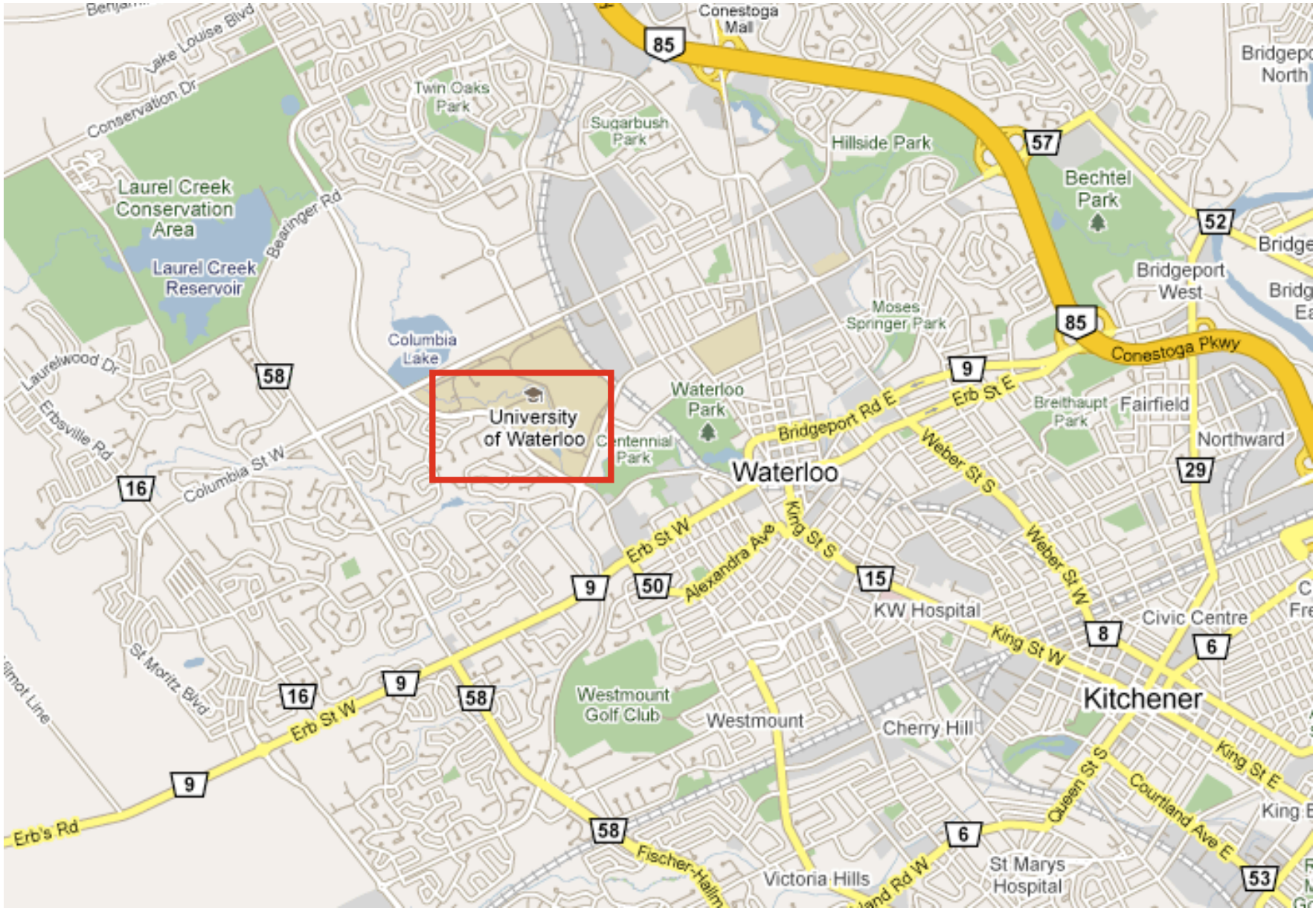
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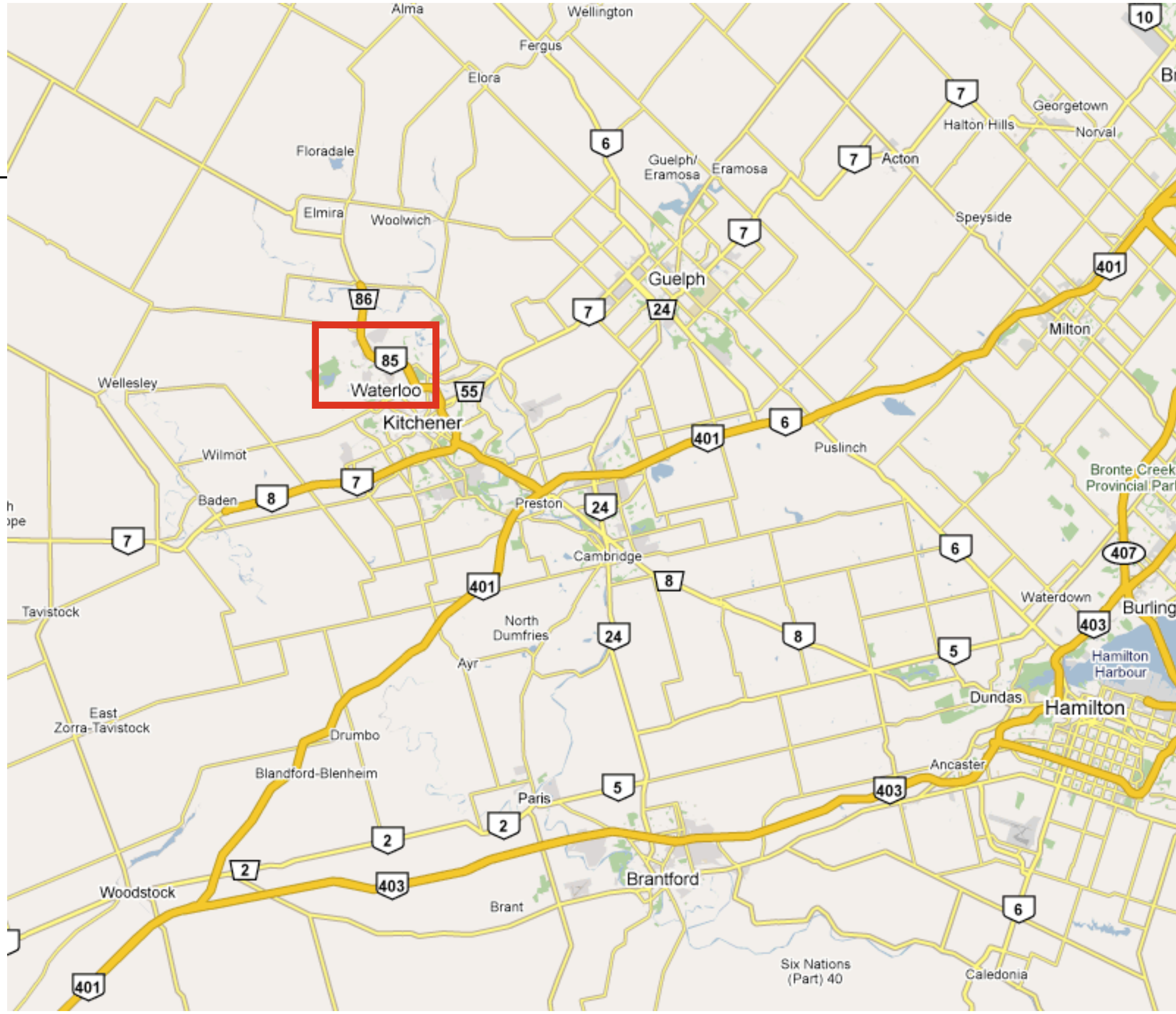

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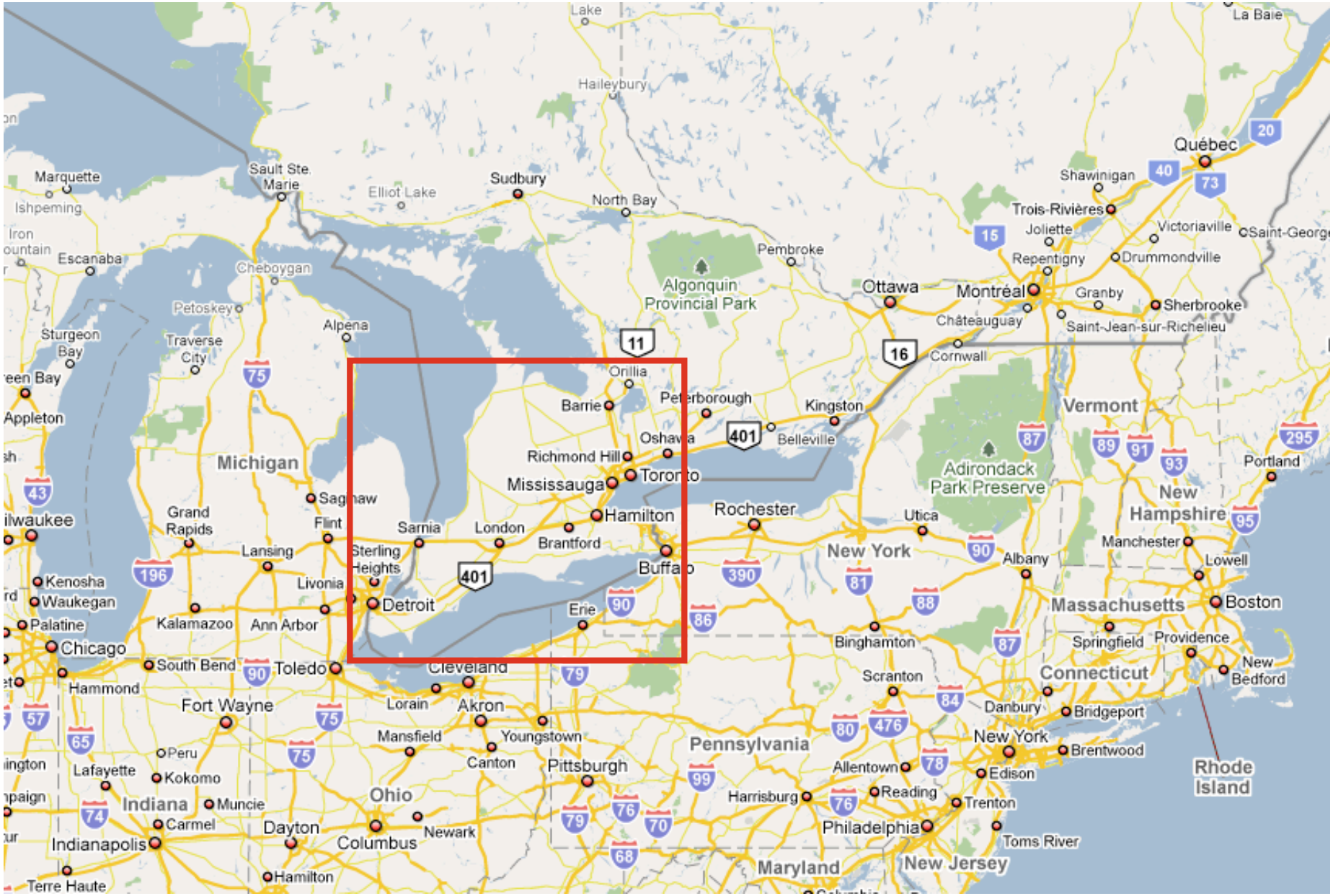
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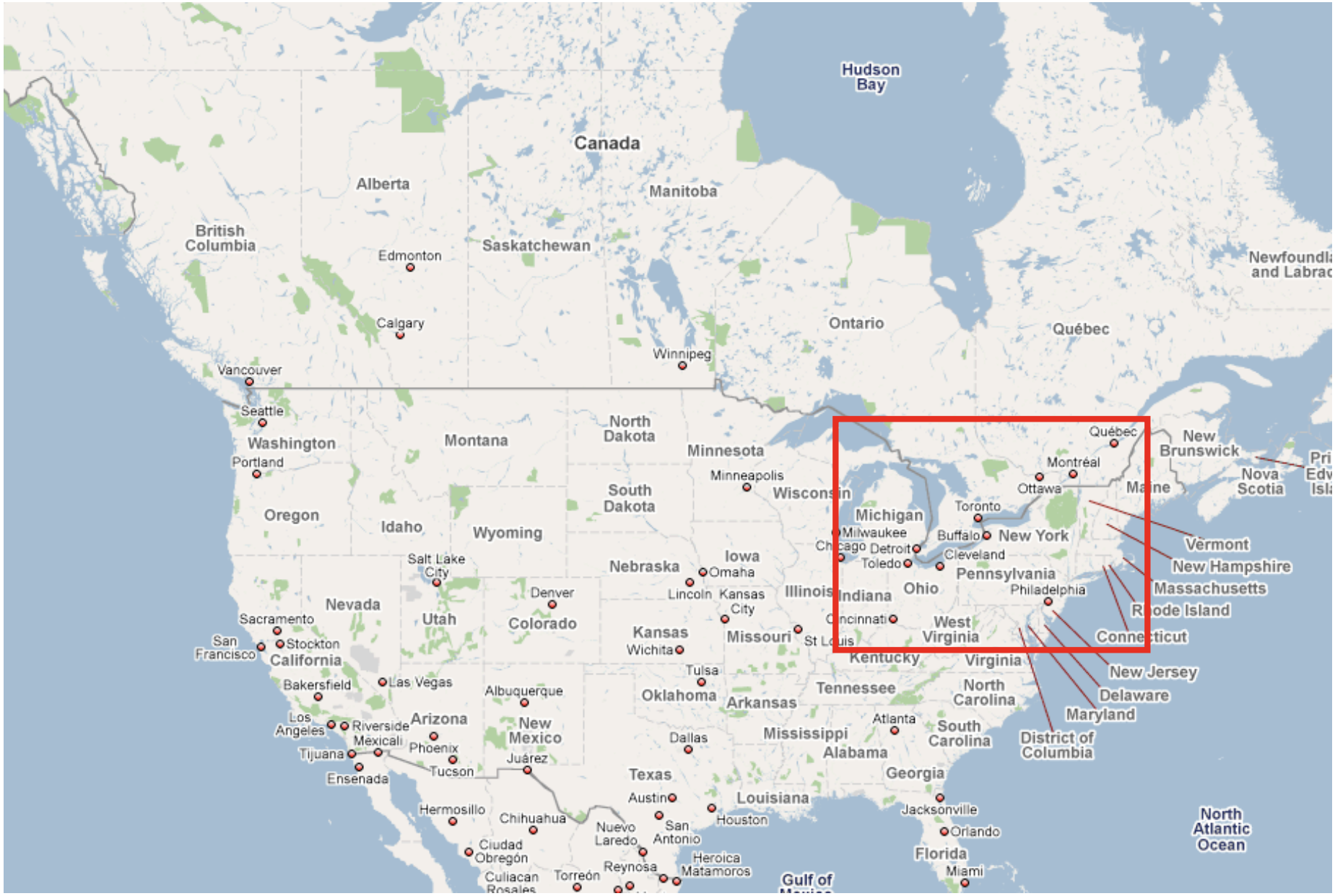
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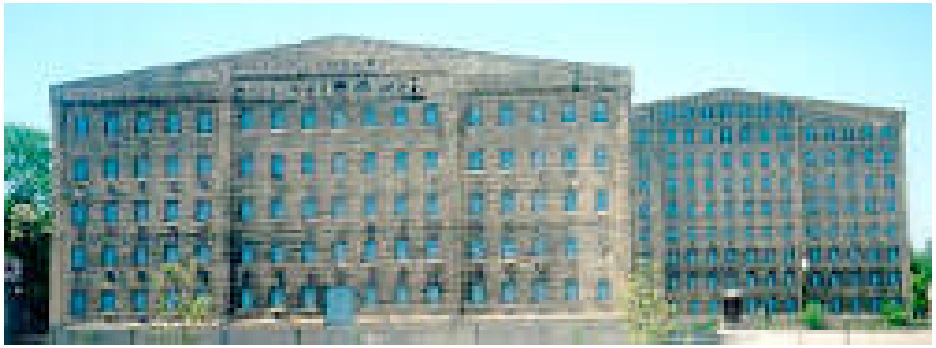
Home of:

- RIM/Blackberry
- Watcom/Sybase
- Maple
- OpenText
- ManuLife



Outline

- Why rural communication?
- Existing solutions and their problems
- KioskNet
- VLink overview
- Architecture
- Use cases
- Conclusions

Why rural communication?

- Access to timely, context-specific information can greatly benefit citizens of developing countries
- Farmers
  - best agricultural practices
  - crop inputs and treatments
  - market prices
- Health workers
  - diagnosis
  - treatment
- Citizens
  - government services

Example: agricultural information

- aAqua project (IIT Bombay, India)
  - Bulletin board system allows farmers to consult with agricultural experts
- Some questions posted recently:
  - How much money can you make from a Jersey cow worth Rs. 20,000 (~$500) in a year?
  - I want information of producing and implementation of Jatropha plant for Bio-Diesel.
  - We have at our disposal 10-12tonnes of aloe vera plants/leaves for sale. Parties interested in purchasing please catch us at 0-9864031770

Low cost communication and access to information…

- Allows better decision making
- Improves worker productivity
- Integrates economies into the world market
- Prevents `leakage' of development funds
- Promotes an informed citizenry and a participatory democracy

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Information access today

- Mostly one-way
  - Radio
  - TV
  - Newpapers
  - Magazines
- Inadequate
  - cannot be personalized - not contextual

Two-way (contextual) information flow

- Possible using newer technologies
  - Cell phones
  - Internet
- But can be expensive
  - Rural poor are unlikely to get good connectivity any time soon
  - Revenue per sq. km << cost per sq. km
- Can we provide reliable connectivity for $1/person/year?

How to reduce costs?

- Share the cost of technology
- Share the cost of *knowing* how to use the technology

Information Kiosk

Kiosk connectivity options

- Dial-up
  - Slow (28 kbps) and flaky
- Satellite (Very Small Aperture Terminals)
  - Expensive and slow
  - Spare parts are hard to get
- Long range WiFi / WiMax
  - Experimental
  - Expensive up-front cost (for 18m tower)
- Cellular broadband (3G)
  - Low penetration because of high upfront costs

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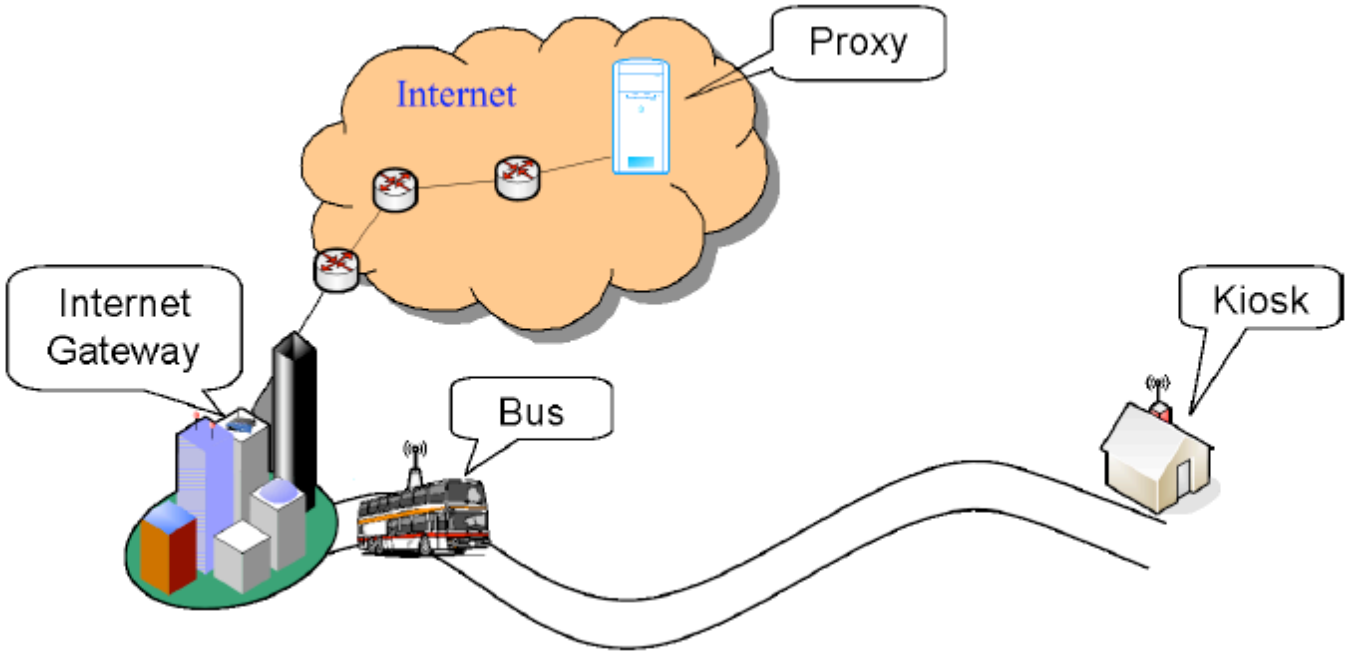
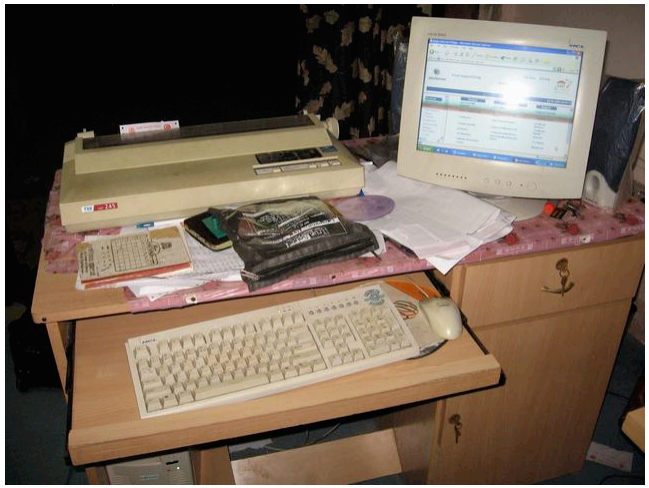
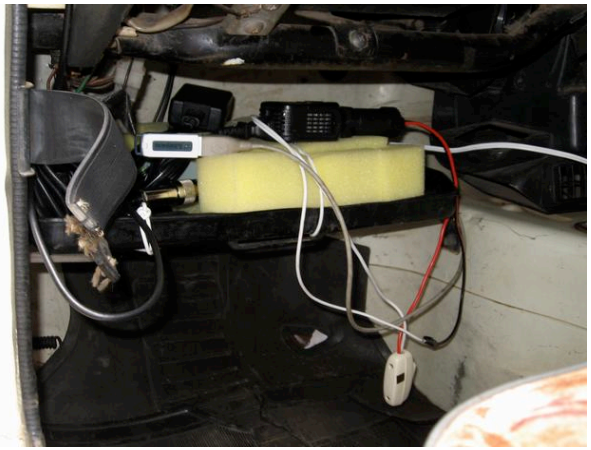
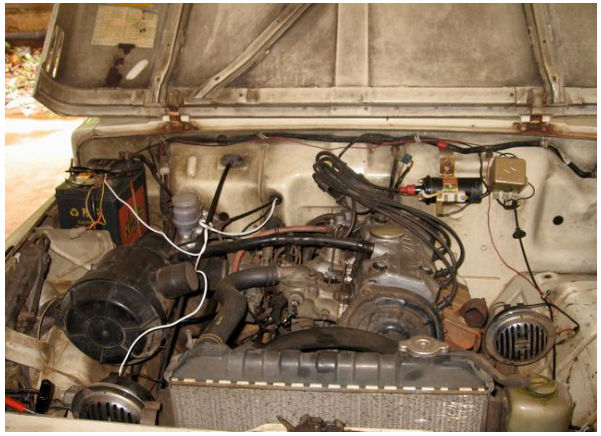
KioskNet (2005-2008)



Trade delay for cost





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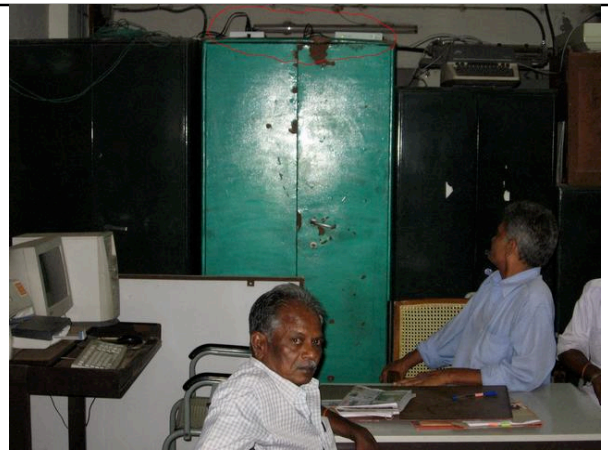

Experiences

- Single-board computers are not mass-market
  - hard to debug and maintain
- Vehicular environment is harsh
  - failure
  - theft
- Difficult to get agreement from transportation providers

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VLink (2009)

- Addresses problems with KioskNet
  - Reuses existing Windows and Linux desktops
  - Software -only solution
  - No computer in vehicle
  - No need for buy in from transportation authorities
  - and MUCH cheaper!
- Leverages USB memory sticks (KeyLink) and SMS (SMSLink)

KeyLink

- USB Keys
  - cheap
  - robust
  - huge capacity
  - easy to transport

Ideally suited to developing countries

KeyLink

- Problems with USB keys
  - manually copying files
  - no triggered actions
  - lost key can result in data loss
  - no acks
  - multiple copies?
  - sharing among users

KeyLink

- Uses USB memory sticks to store and forward data
  - file system stores ‘frozen’ packets
  - supports acks and triggered actions
- Data is optionally encrypted with a per-user cryptographic key
  - no user can read any other user’s data
  - if a key is lost, no one can read any data
- Multiple keys can be used
  - can be plugged into nodes in arbitrary order

SMSLink

- Allows reliable transfer over SMS
  - fragmentation and reassembly
  - timeouts and retransmissions
- Using an attached Nokia mobile phone
- Data rates are about 160 bps
  - useful for control or urgent messages

TCPLink

- Allows disconnection-tolerant communication over end-to-end (TCP) links
  - VSAT
  - Long-range WiFi
  - GPRS

SecureConnect

- Makes any link cryptographically secure
  - based on Public Key Infrastructure
- SecurityController signs a node's admin key
- Node admin can sign keys for users at that node
- Every node has the Controller's public key
- Node-to-node secure communication requires sender to have receiver's public key
  - published as a white pages database

Applications

- Email application is shipped with KioskNet
  - allows secure email communication from any node in conjunction with ProxyApp
- VSync
  - keeps two directories in sync
  - one-way and two-way
  - using KeyLink, SMSLink, or TCPLink

Applications

- System is extensible - new applications can be easily added
  - communication by means of a ‘communications directory’
  - runs on a node or thin client
  - apps that require Internet access use a proxy app plugin at an Internet-connected node

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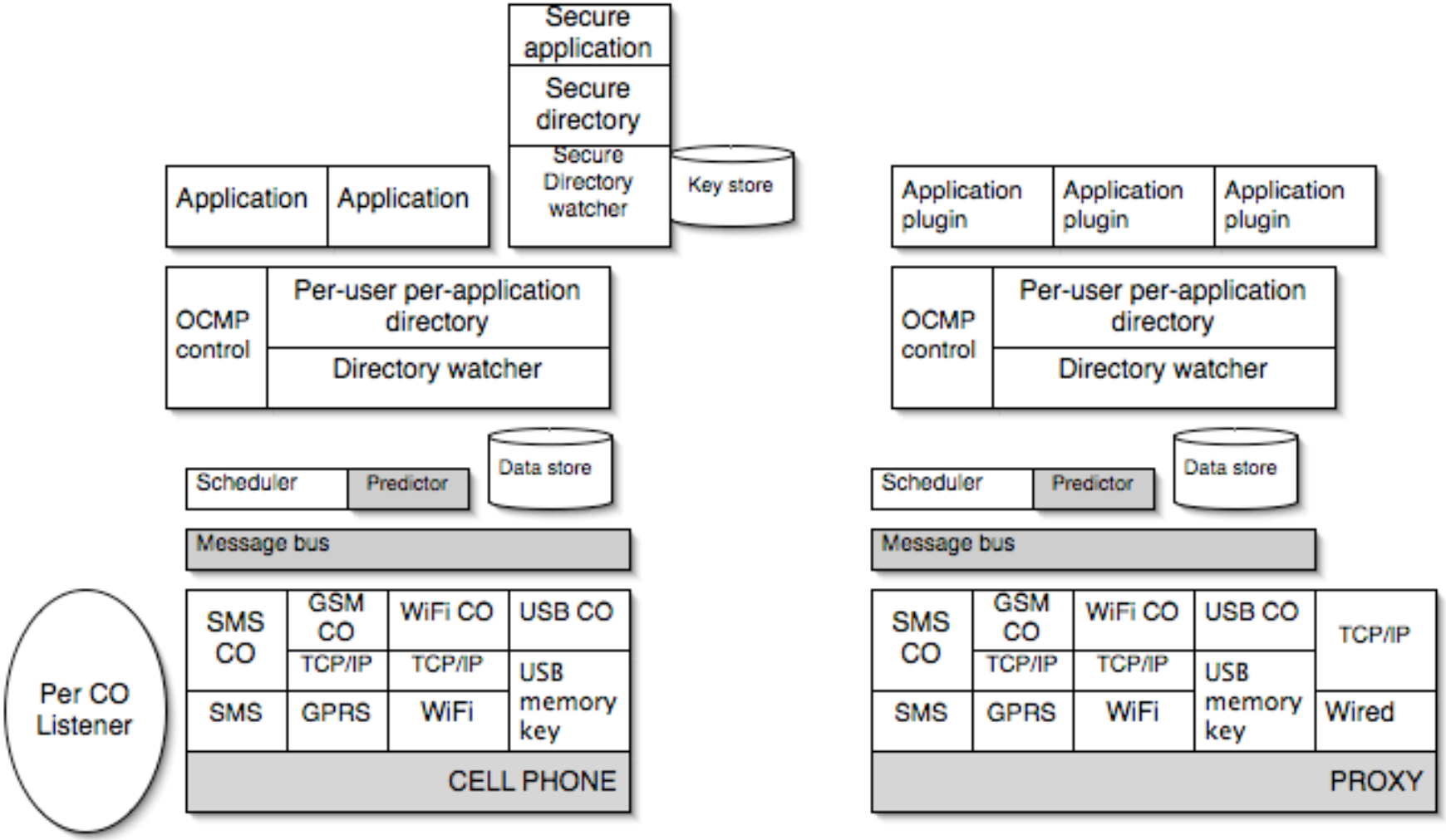
Architecture



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Possible uses

- NGOs for internal communication
- Hospitals for consultation between district hospitals and headquarters
- Rural Business Process Outsourcing (BPO)
- Community Service Centers (kiosks) to offload bulk data transfer
- Educational outreach using audio/video

Evaluations in progress

- East Timor
  - coffee plantation
- India
  - telemedicine
  - community radio
- Always looking for more!

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Conclusions

- Rural communication is potentially world-changing
- Requires technical solutions very different from those in the first world
- KioskNet and VLink are first steps in this direction
  - make innovative use of technical advances in wireless communication and flash memory

Thank you!

- **Grad students** : S. Liang, A. Seth, N. Ahmed, M. Ghaderi, S. Guo, M.H. Falaki, S. Ur Rahman, E. A. Oliver, U. Ismail
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- **Staff Programmer**: D. Kroeker, M. Derakhshani, A. Ganjali
- **Undergrads** : M.Zaharia, P. Darragh, N. Arora, Y. Yin, G. Salmon, G. Wang, M. Liang, M. Thomas, A. Agarwal,Y. Xu, Y. Hu, S. Dube, R. Sethi, C. Ho, C. Tan, A. Leong
- **Affiliated Faculty**: T. Brecht (UW), U. Hengartner (UW), S. Prasad (IIT Delhi), H. Saran (IIT Delhi)
- **Staff support**: G. Chopiak

Gaining robustness

- MAC
  - Avoid the fringe
  - Avoid performance coupling
- Network
  - Flooding-based routing
  - Priority for less-replicated data items
  - Death certificates
- Transport
  - Hop-by-hop TCP
- Application
  - Directories
- Overall
  - Use databases for volatile state
  - Choose simpler solutions