Network Usage and Performance Analysis in Resource-Constrained Systems

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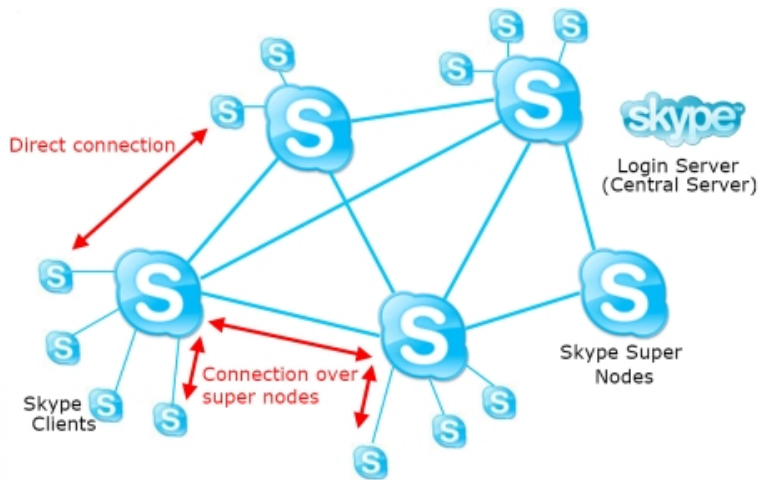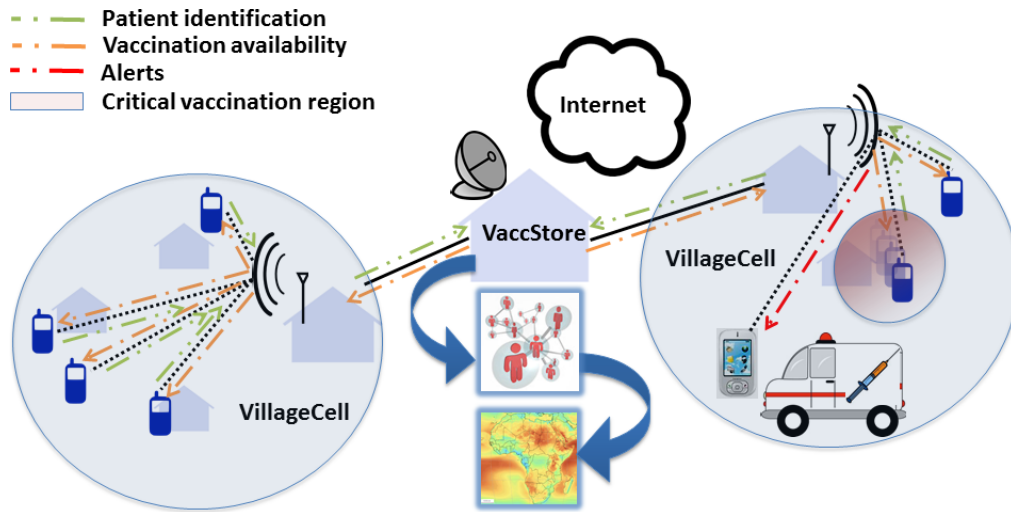Faculty *of Computer and Information Science*

Ljubljana, Jan 2015.

Networked Systems

Systems composed of dynamic units that interact with each other over an information exchange network
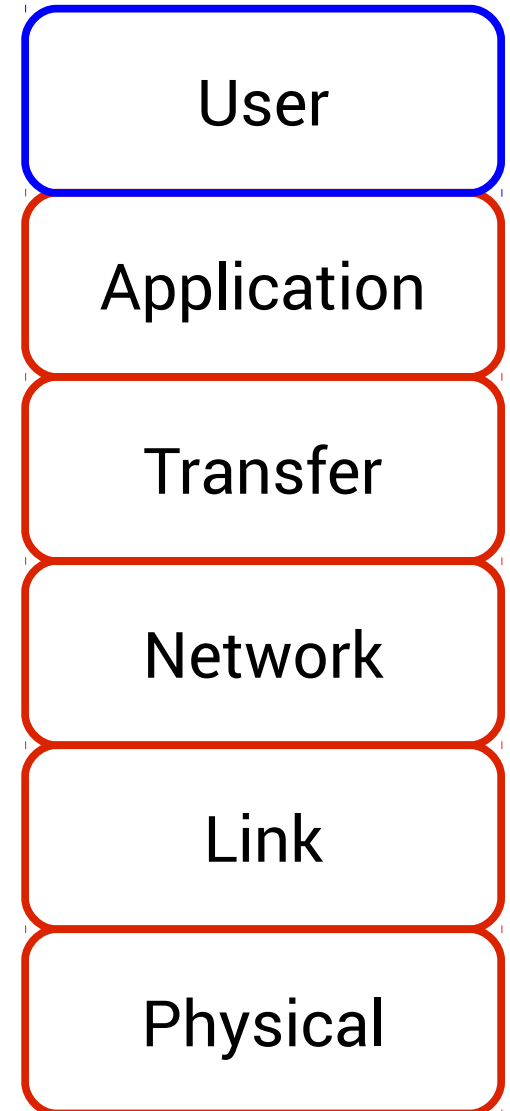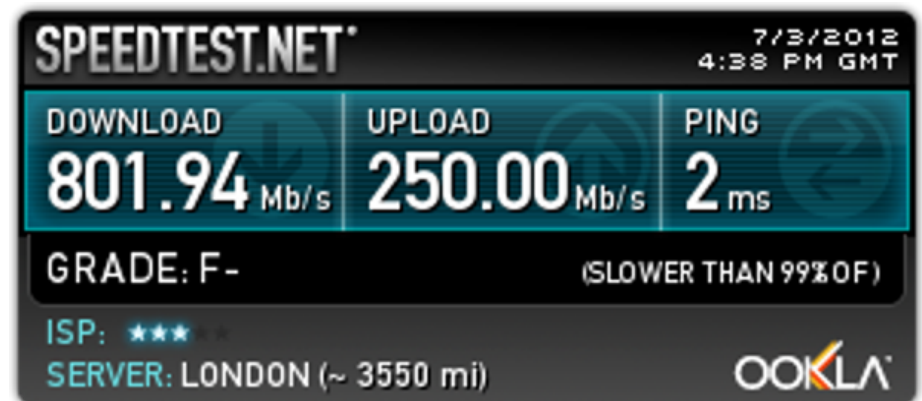
Networked Systems

Networked Systems

- A range of applications
  - Video/voice communication,
    photo exchange, flight control systems

- Varying in size
  - File sharing via a local server,
    planet-wide online social network

- Any underlying connection technology
  - Ethernet, WiFi, Bluetooth

| User |
| Application |
| Transfer |
| Network |
| Link |
| Physical |

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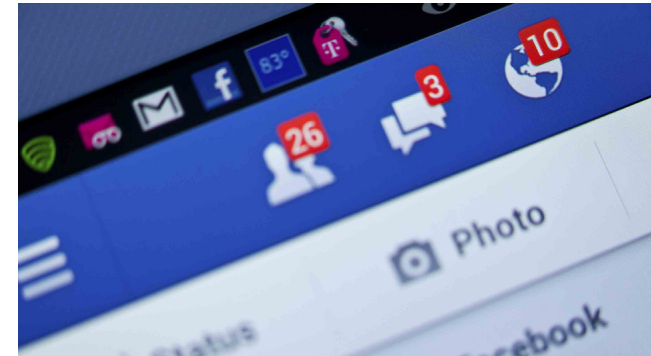Faculty of Computer and
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Networked System Measurements

- Performance measurements

Networked System Measurements

- Performance measurements

- Usage measurements

Networked System Measurements

- Performance measurements

- Usage measurements

- Surrounding context measurements

Networked System Measurements

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Performance Measurements

Measure	Tool
Reachability/routing	`ping, traceroute`
Wireless signal quality	`iwconfig, iwlist`
Latency/delay	`ping,` application level measurements
Throughput	`iperf, iptraf`
Error rate	`netstat, iptraf`
Jitter	`iperf`
…	network programming (sockets, packet injection, …)

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Usage Measurements

Measure	Tool
Traffic content	`wireshark, tcpdump`
Traffic summary	`ipsumdump`
Web usage	error logs, proxy logs, cache stats, `calamaris`
User experience	focus groups, online surveys, interviews
...	Scripting languages, content crawlers, be creative!

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Why Measurements?

Troubleshooting

System management

Innovation

Data-driven prototype evaluation

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Case Study:
Examining Alternative OSN Architectures

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OSN Architecture − Facebook

- Centralised architecture
    - Poor usability outside North America and Europe
    - High cost of infrastructure in new markets
    - Scalability

Content Distribution Network (CDN)

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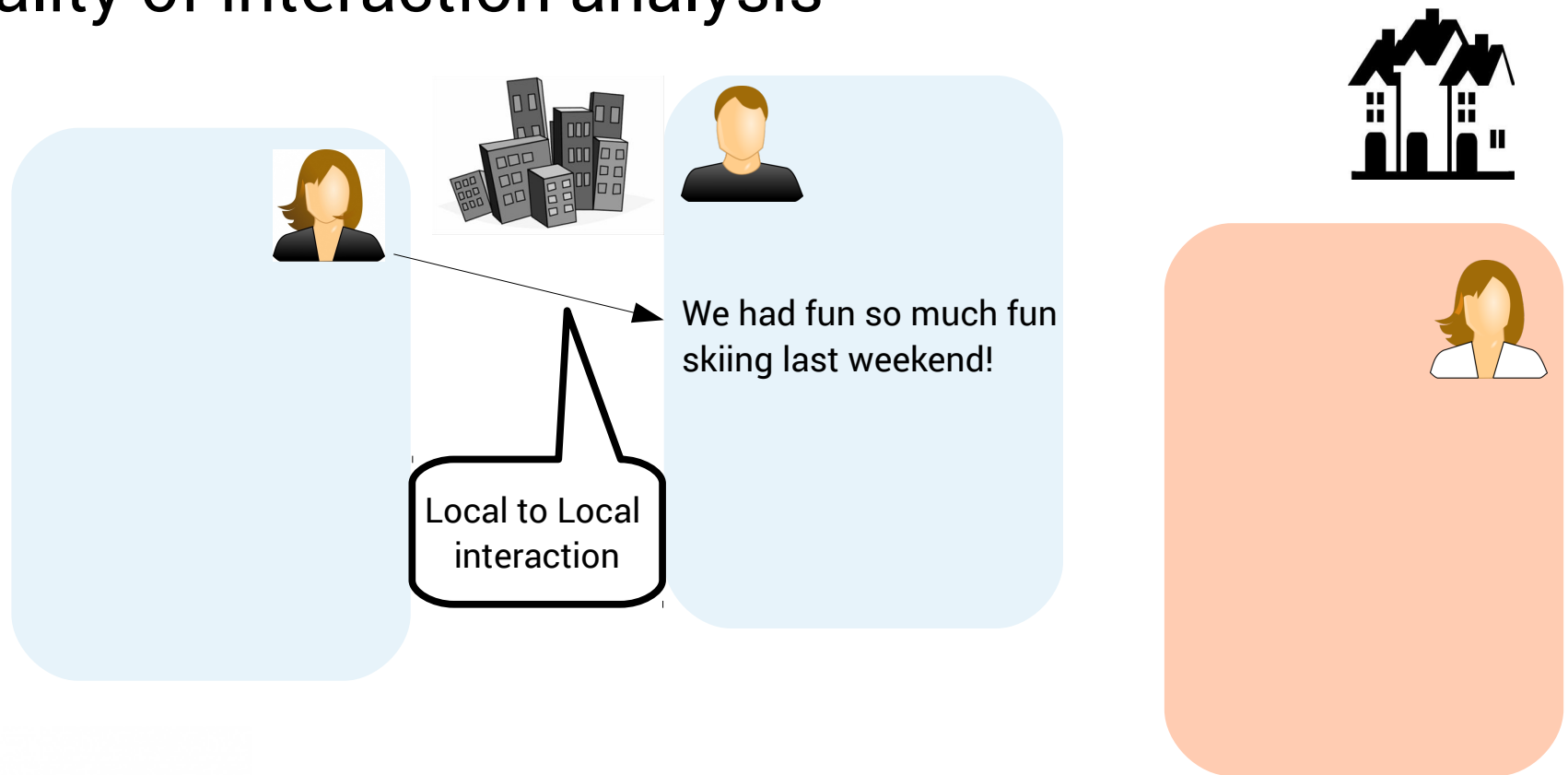Faculty of Computer and
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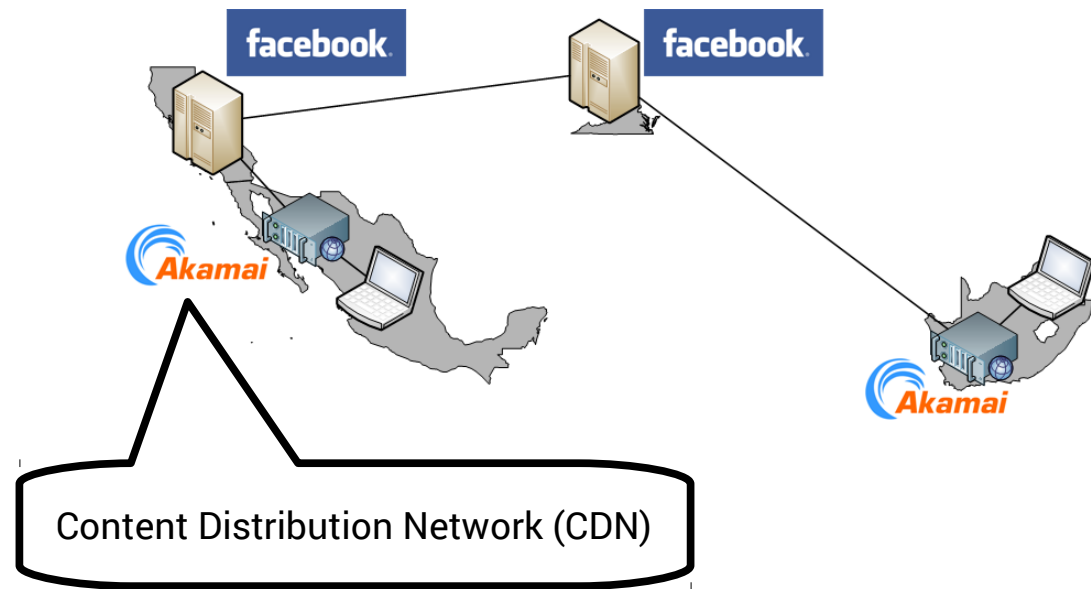
OSN Architecture – Facebook

- Can we improve it?
  - Analyse the usage to identify opportunities

  - Measure the extent of the problem

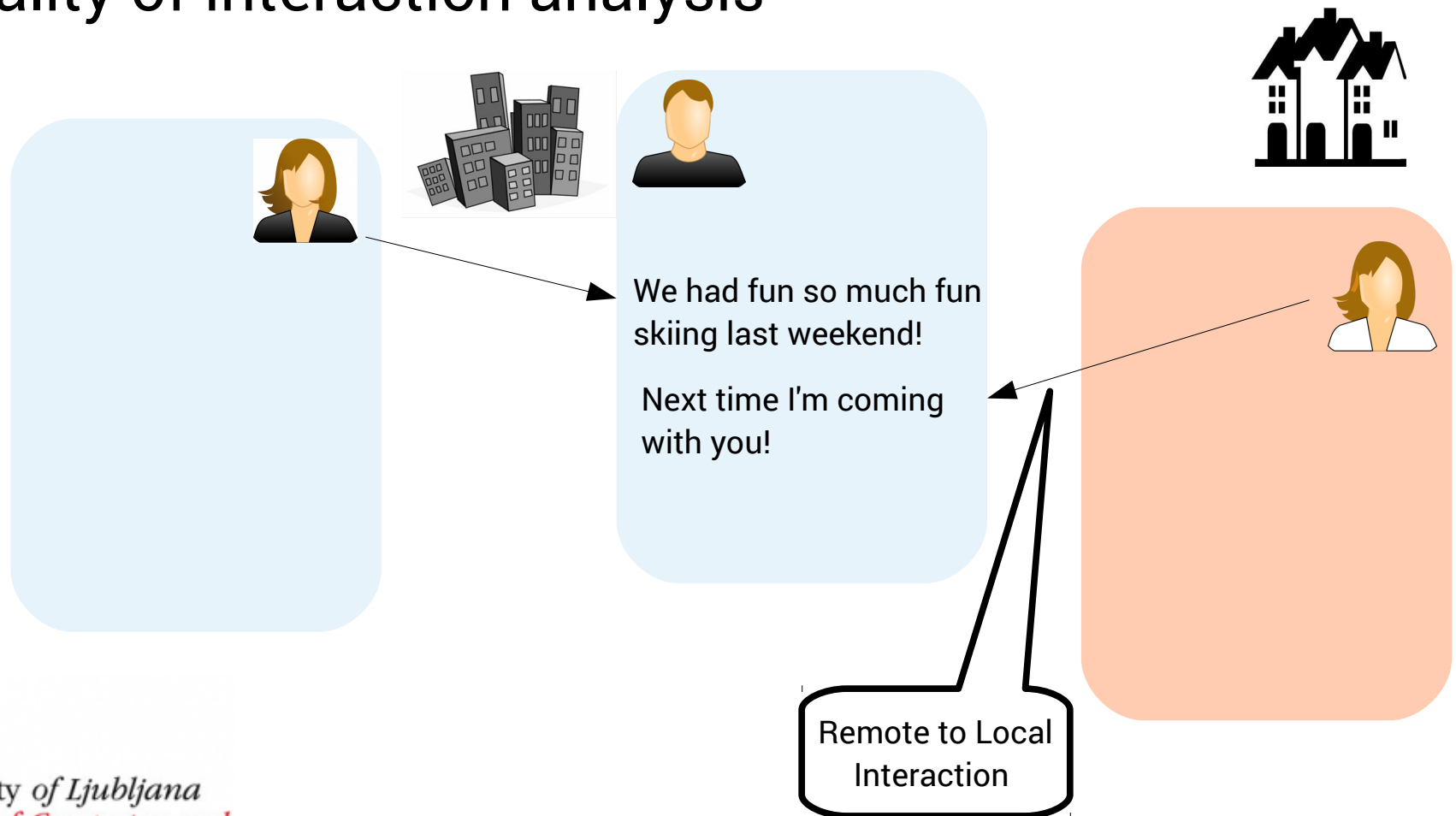 - Evaluate solutions with real-world data
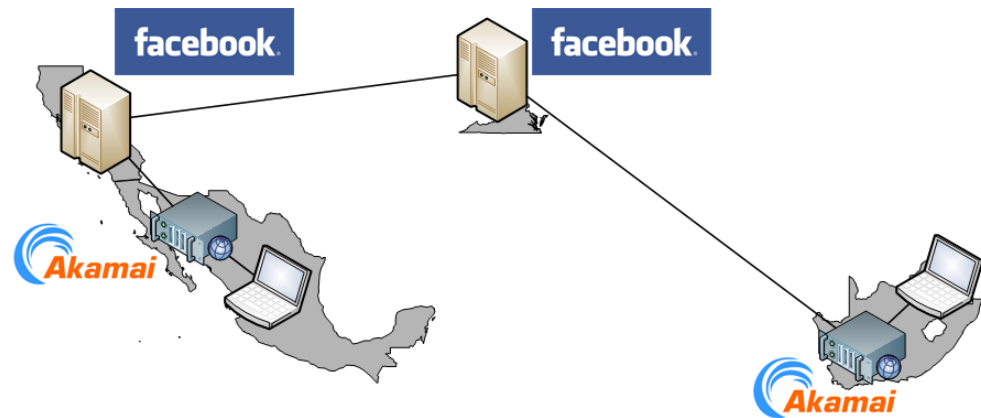
Identify Opportunities – Usage Analysis

- Data: ~10 million profiles from FB [Wilson et al. 2009]
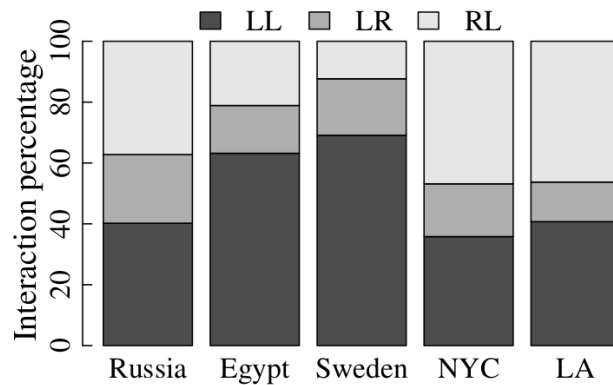- Locality of interaction analysis

We had fun so much fun skiing last weekend!

Local to Local interaction

Identify Opportunities – Usage Analysis

- Data: ~10 million profiles from FB [Wilson et al. 2009]
- Locality of interaction analysis

We had fun so much fun skiing last weekend!

Next time I'm coming with you!

Remote to Local Interaction

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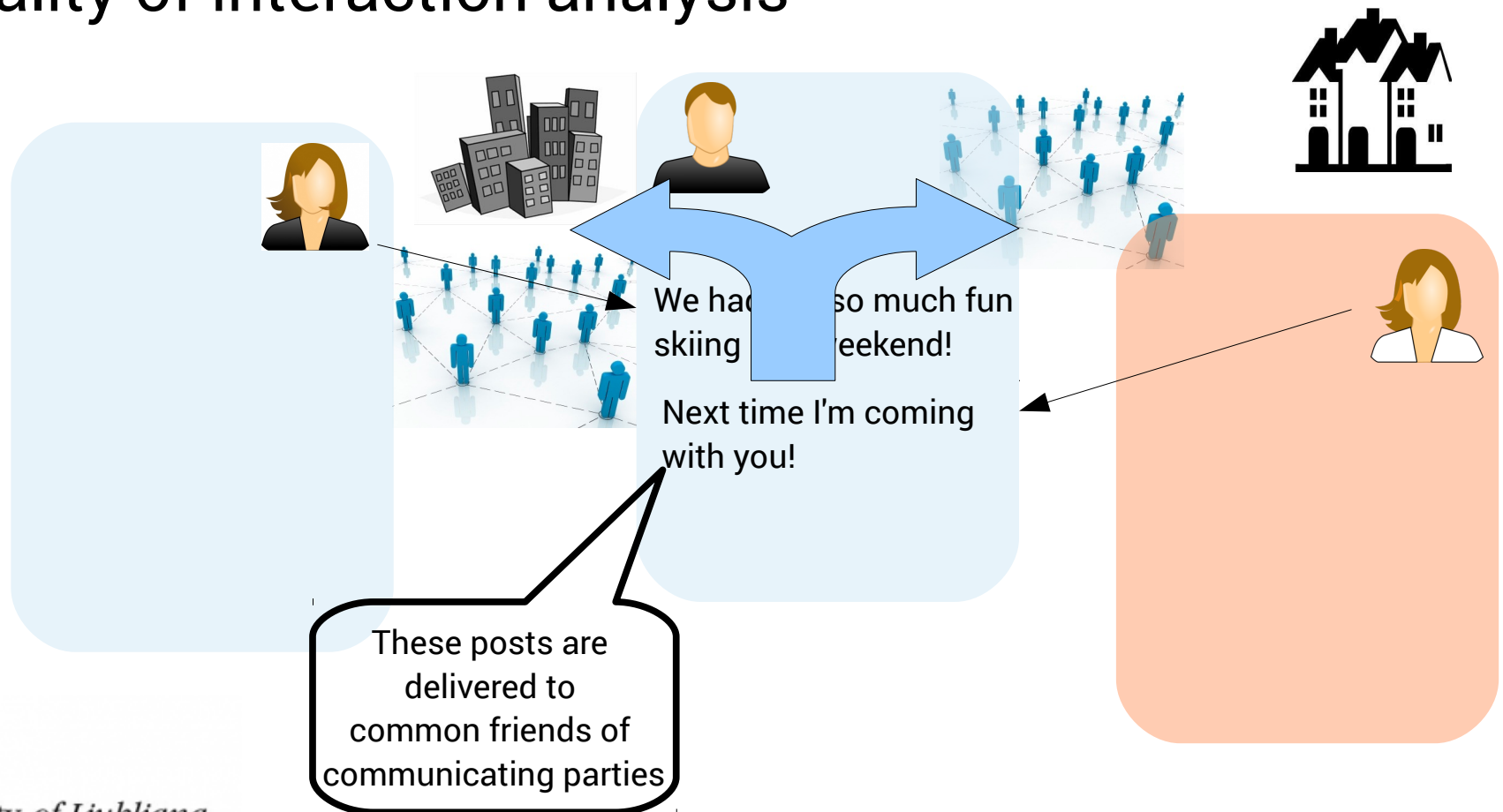Faculty *of Computer and Information Science*

Identify Opportunities –
Usage Analysis

- Data: ~10 million profiles from FB [Wilson et al. 2009]
- Locality of interaction analysis
  - Count L-L, L-R, R-L in each region

Identify Opportunities − Usage Analysis

- Data: ~10 million profiles from FB [Wilson et al. 2009]
- Locality of interaction analysis

We had so much fun skiing weekend!

Next time I'm coming with you!

These posts are delivered to common friends of communicating parties

Identify Opportunities – Usage Analysis

- Data: ~10 million profiles from FB [Wilson et al. 2009]
- Locality of interaction analysis
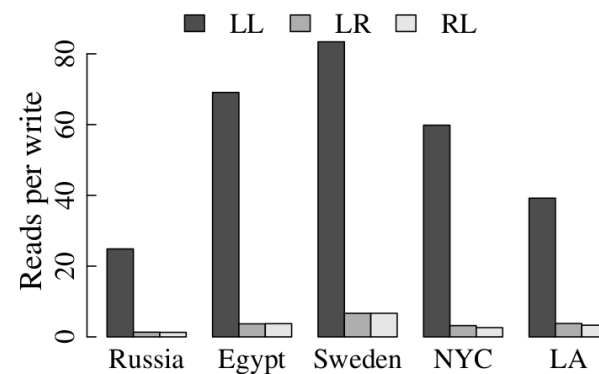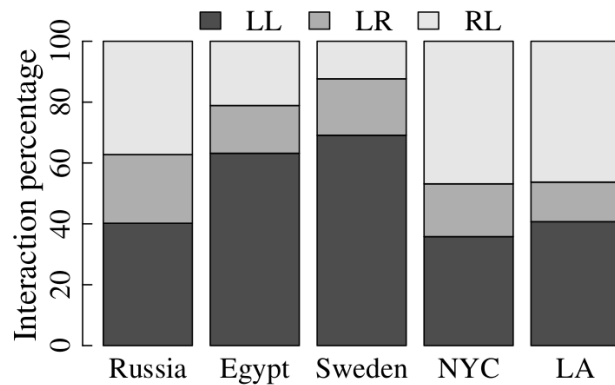 - Count L-L, L-R, R-L in each region

  - Count delivery ratio of posts

Usage Analysis Conclusion:
High Locality of Interaction

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Measure the Problem – Performance Analysis

- Facebook transaction analysis:
  - How much, and what kind of data is transferred on Facebook?

  - Network traces - `Wireshark`

Photo post

```
TRANSFER    FROM    TO      BYTES     COMMENT
1           user    CA      1510      #upload script request
2           CA      user    5703      #upload script
3           user    CA      136802*   #photo and post text
4           CA      user    7168      #display markup
5           user    CDN     495       #display image request
6           CDN     user    3819*     #display jpeg
```
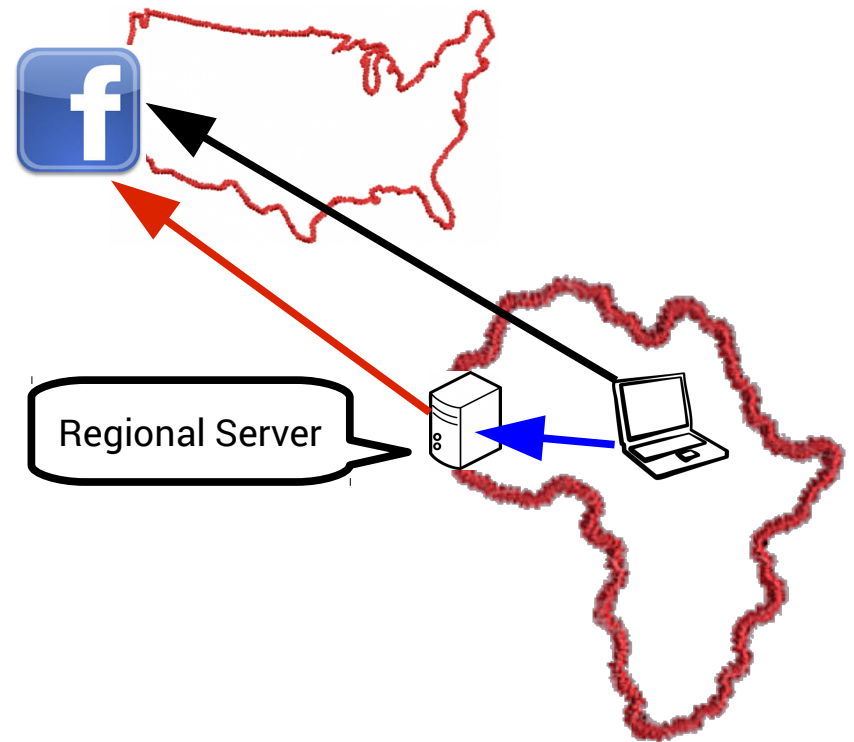
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Measure the Problem – Performance Analysis

- Internet path analysis
  - Connection quality between end-users and Facebook infrastructure

  - Latency – `ping`

  - Throughput – `iperf`

Regional Server

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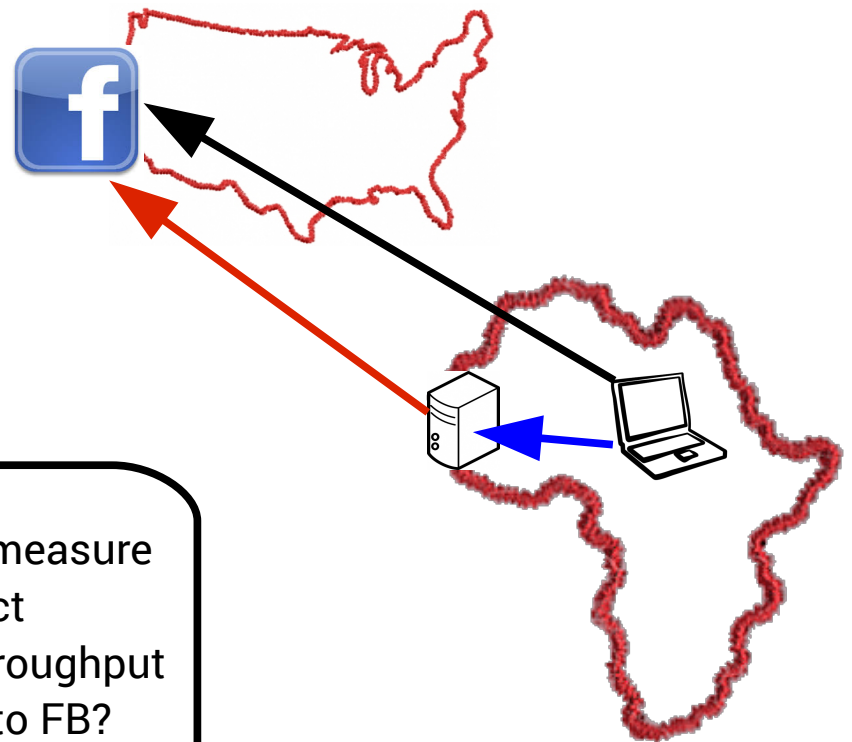Faculty of Computer and
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Measure the Problem – Performance Analysis

- Internet path analysis
  - Connection quality between end-users and Facebook infrastructure

  - Latency – `ping`

  - Throughput – `iperf`

  - Approximate end points with `planetlab` nodes

Why don't we measure the exact latency and throughput from users to FB?

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Measure the Problem – Performance Analysis

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  - Connection quality between end-users and Facebook infrastructure

  - Latency – `ping`

  - Throughput – `iperf`
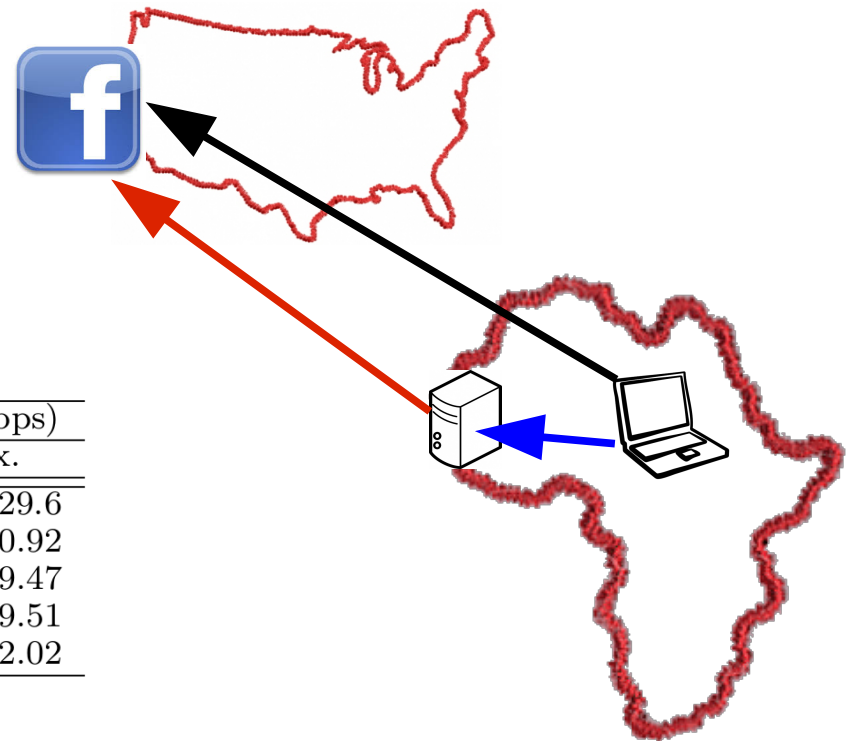
  - Approximate end points with `planetlab` nodes

Region	Latency (ms)			Loss (%)			Capacity (Mbps)		
	dir.	prox.		dir.		prox.	dir.	prox.	
Russia	148	115	31	6.1	0	1.8	29.6	367	29.6
Egypt	164	176	67	5.8	0	5.8	0.92	736	0.92
Sweden	104	95	14	0.32	0	2.9	9.47	188	9.47
NYC	74	43	33	0.75	0	0.6	9.51	99	9.51
LA	27	9.1	18	0.50	0	0.4	2.02	228	2.02

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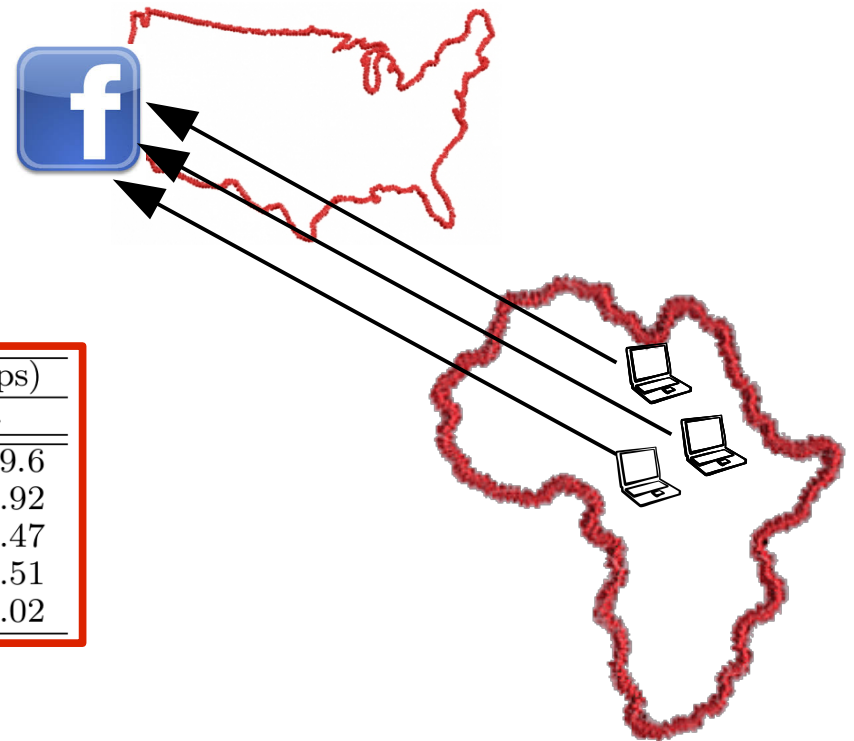Faculty of Computer and
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Performance Analysis Conclusions:

- Parts of a transaction can be sent irrespective of the data
- Server to FB connection is much better than end-user to FB connection

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Solution: Alternative Infrastructure

- 1) TCP proxying with regional servers
  - Split connection at a regional server

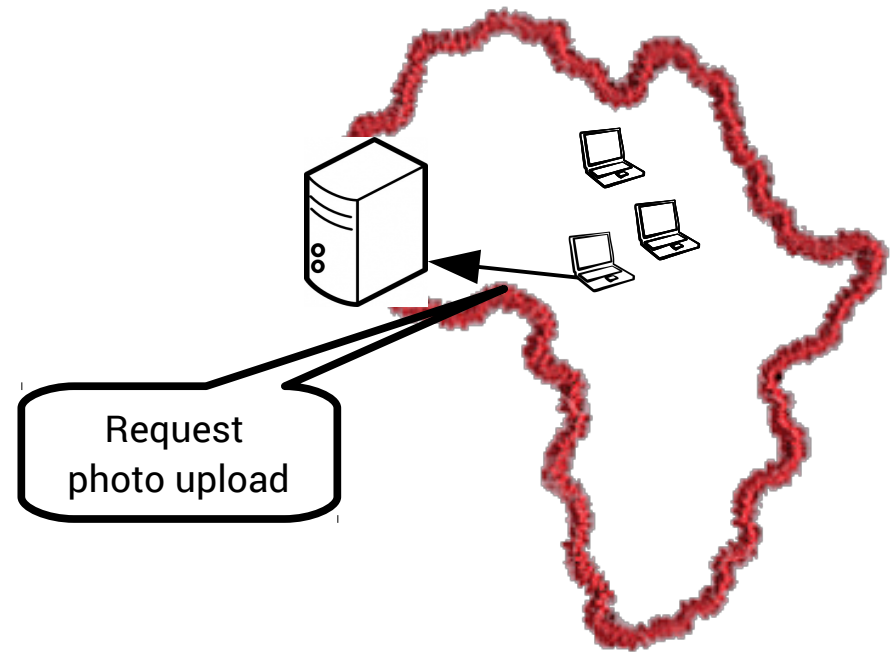| Region	Latency (ms)			Loss (%)			Capacity (Mbps)		
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Solution: Alternative Infrastructure

- 1) TCP proxying with regional servers
  - Split connection at a regional server
  - Isolates the effect of poor links
  - Allows a wider TCP window
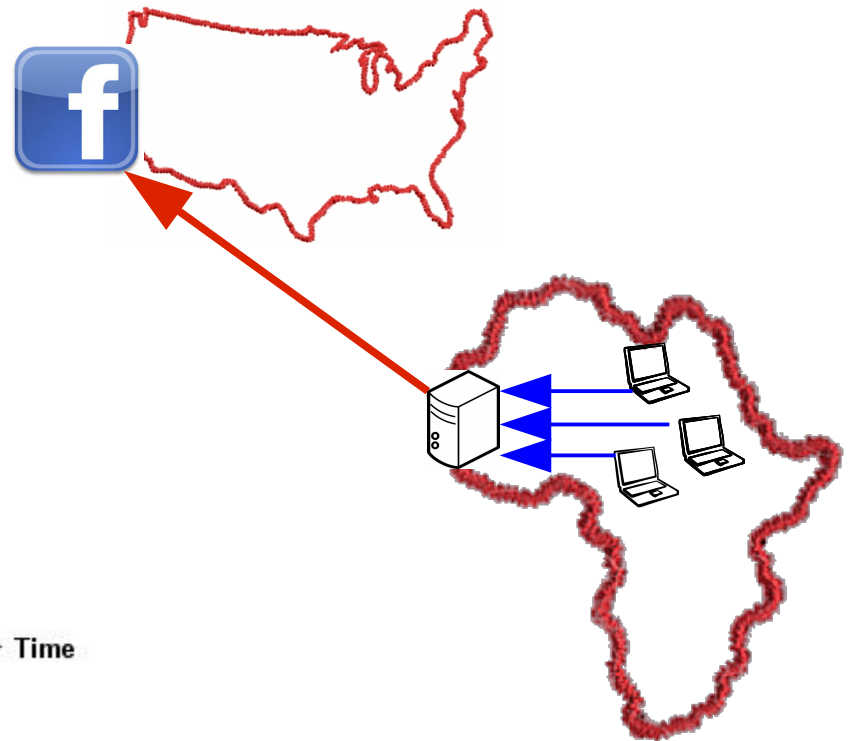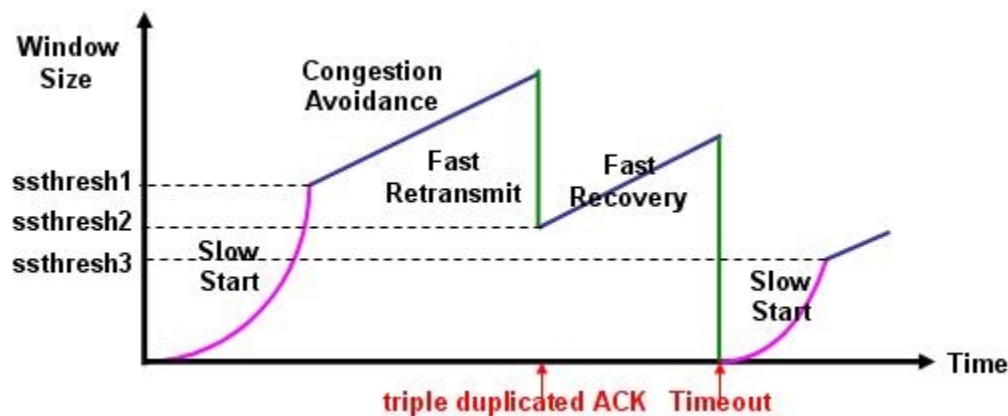
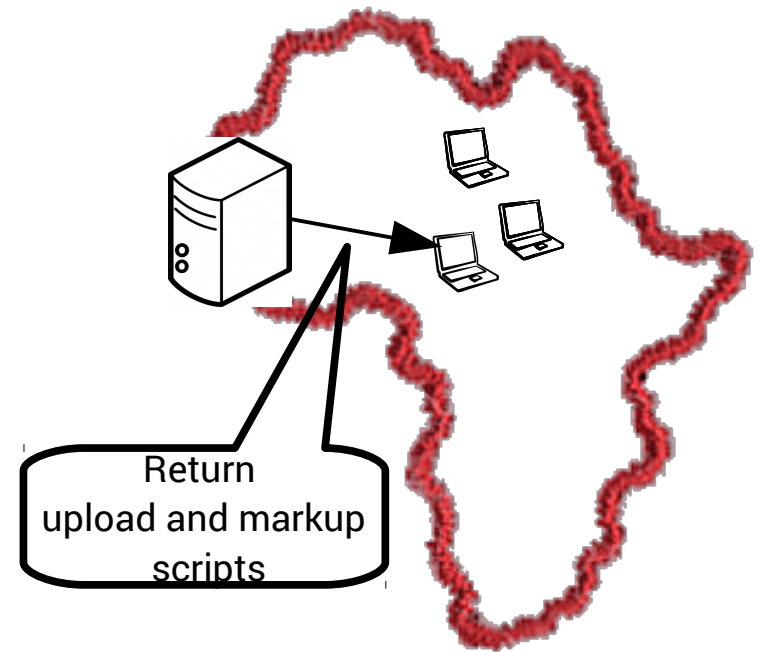University of Ljubljana
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Solution: Alternative Infrastructure

- 2) Regional OSN cache
  - Regional server:
    - Regional social graph
    - Cache recent local content

Request photo upload

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Solution: Alternative Infrastructure

- 2) Regional OSN cache
  - Regional server:
    - Regional social graph
    - Cache recent local content

```
TRANSFER   FROM    TO      BYTES      COMMENT
1          user    CA      1510       #upload script request
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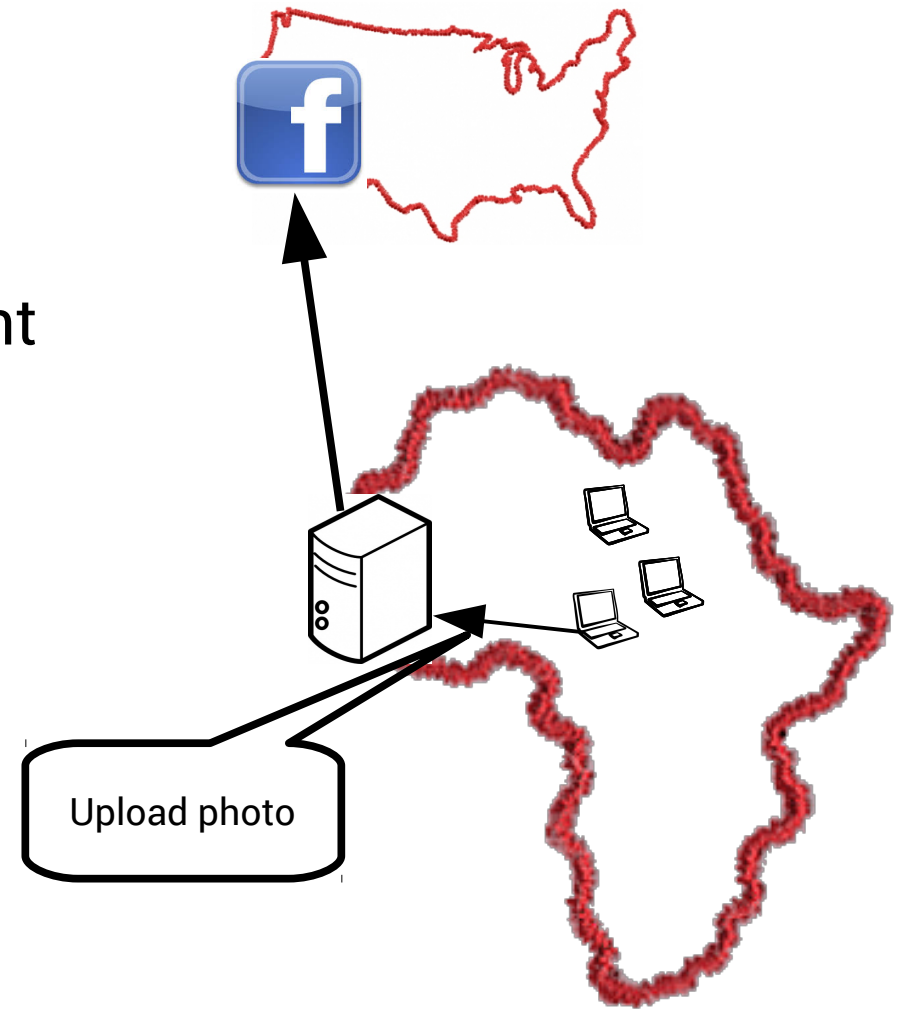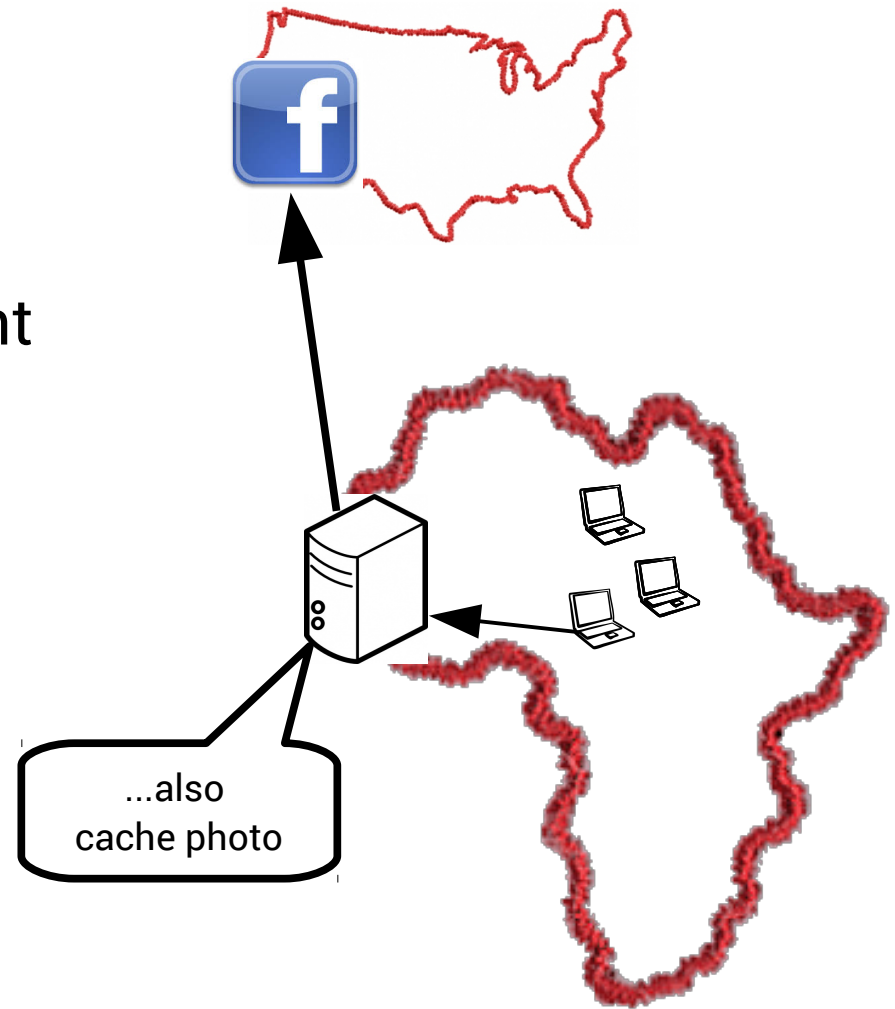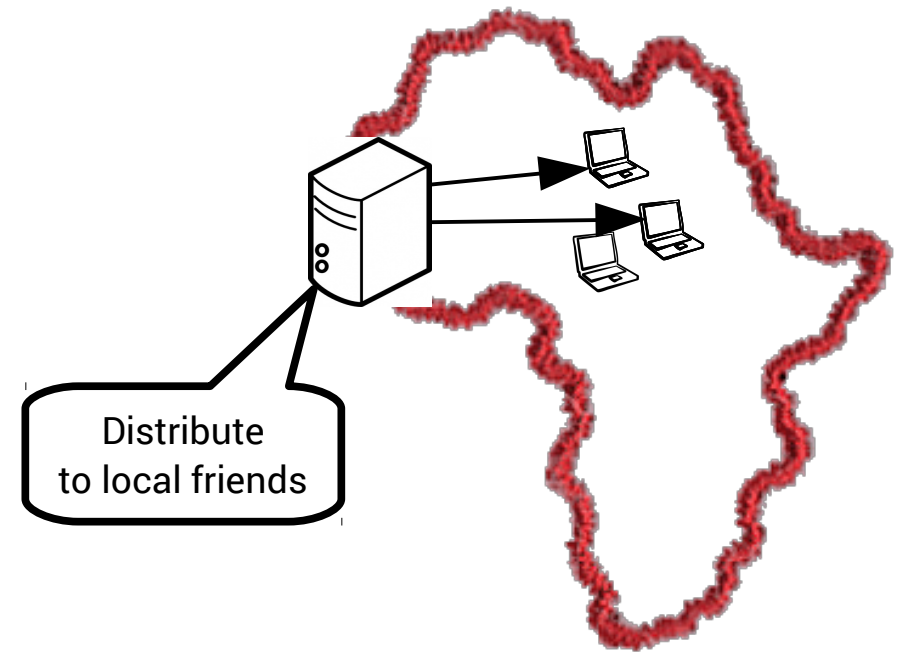
Return upload and markup scripts

Solution: Alternative Infrastructure

- 2) Regional OSN cache
    - Regional server:
        - Regional social graph
        - Cache recent local content

Upload photo

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Solution: Alternative Infrastructure

- 2) Regional OSN cache
  - Regional server:
    - Regional social graph
    - Cache recent local content

...also cache photo

Solution: Alternative Infrastructure

- 2) Regional OSN cache
  - Regional server:
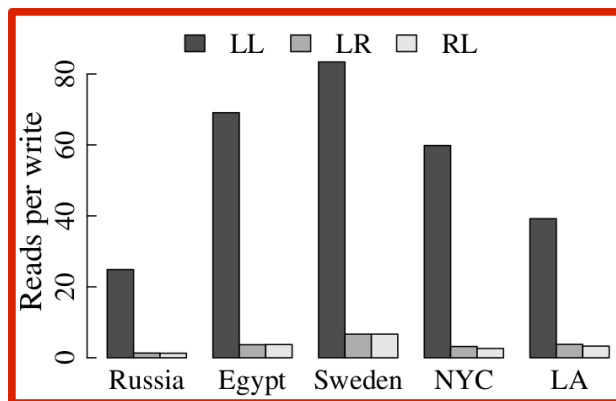   - Regional social graph
    - Cache recent local content
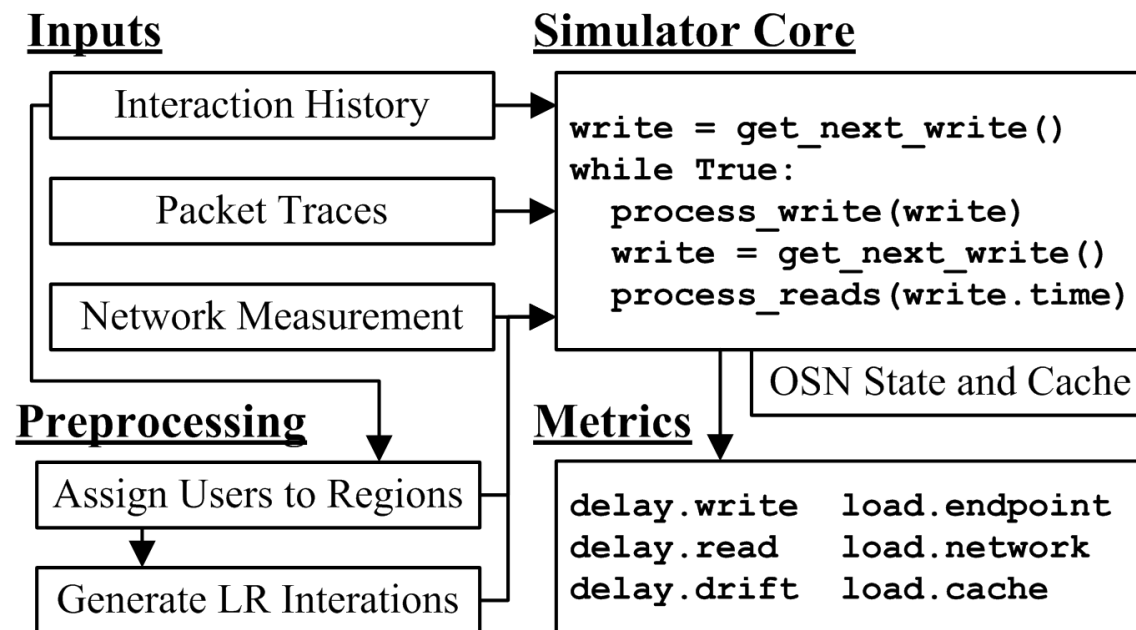

Distribute to local friends

Evaluate Solutions

- Data trace-based evaluation
  - Replay all the interactions identified in the dataset

  - Assign the measured "cost" to each interaction

  - Process interactions according to:

    - Current FB architecture

    - Regional TCP proxy architecture (solution 1)

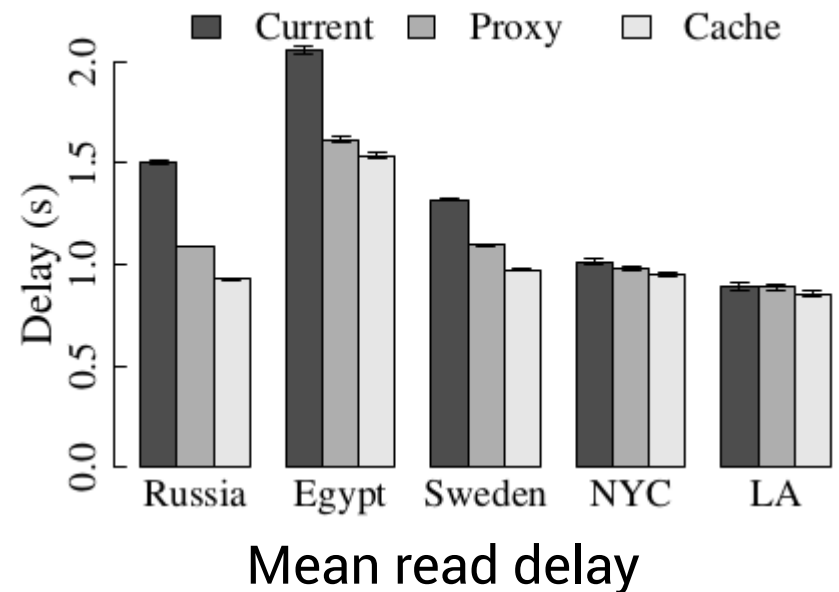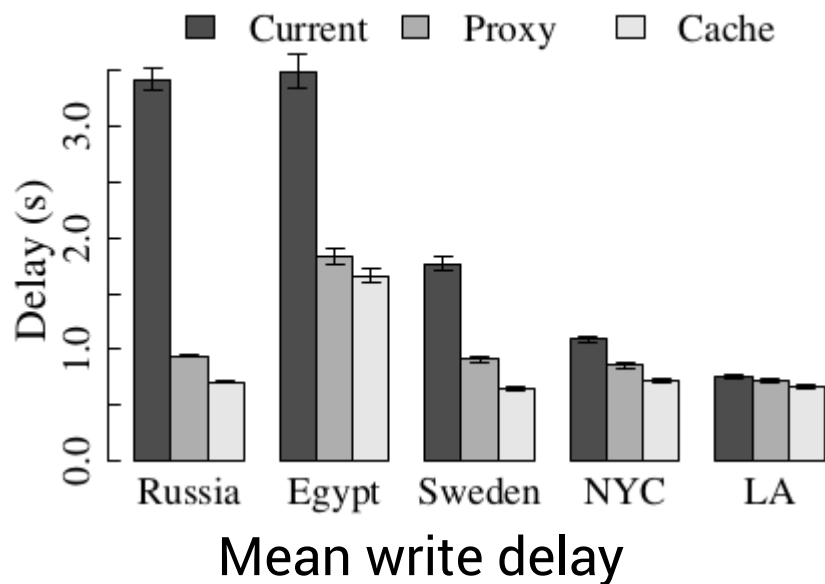   - Regional OSN cache architecture (solution 2)

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Evaluate Solutions

- Data trace-based evaluation

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Evaluate Solutions

- Results
  - Delay

Mean write delay

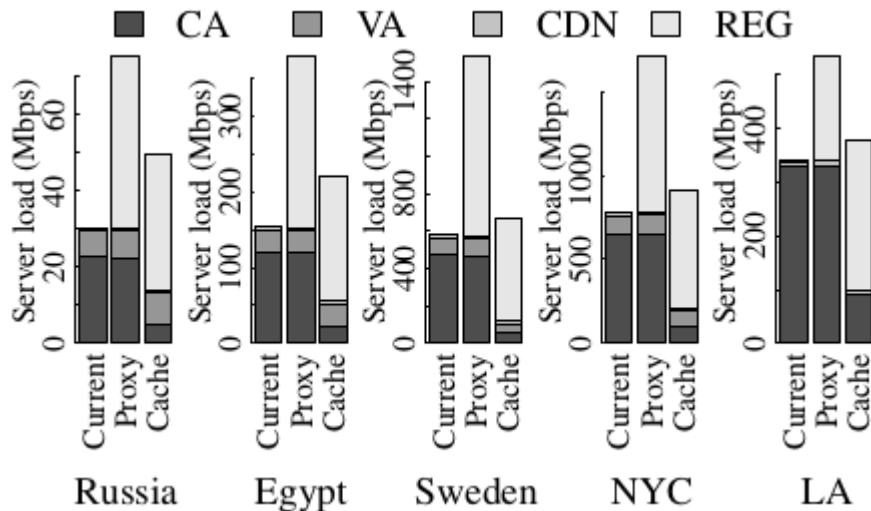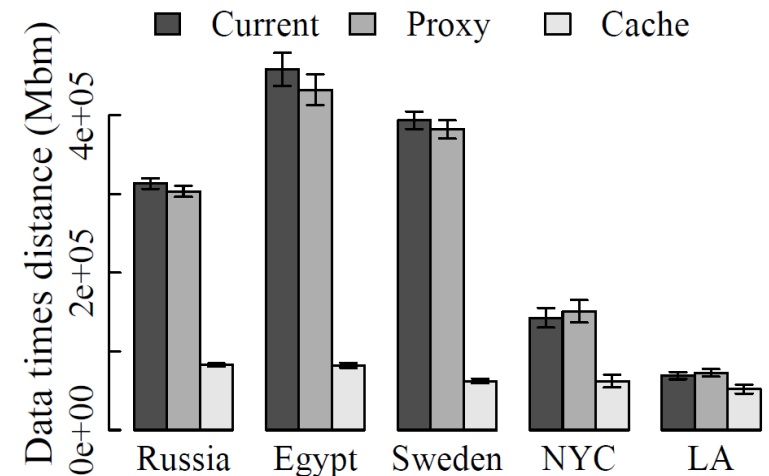Mean read delay

Evaluate Solutions

- Results
  - Server and network load

Server endpoint load

Network load

Think about
the economic impact!

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Case Study Conclusions

- Network analysis revealed:
    - Bottlenecks in OSN data transfer
    - Locality of interest
- Proposed alternatives:
    - Regional TCP proxying
    - Regional cache servers
- Evaluation:
    - Trace-based simulation
    - Improved user experience and lower system load

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References

- Tools and tutorials:
  - www.wireshark.org/docs/wsug_html_chunked/

  - Read man pages for iperf, tcpdump, netstat, ping, traceroute

- Papers:

  - Vern Paxons, **"Strategies for Sound Internet Measurement"**, IMC'04
    www.icir.org/vern/papers/meas-strategies-imc04.pdf

  - Christo Wilson, Bryce Boe, Alessandra Sala, Krishna P. N. Puttaswamy, and Ben Y. Zhao **"User Interactions in Social Networks and their Implications"** EUROSYS'09
    http://www.ccs.neu.edu/home/cbw/pdf/interaction-eurosys09.pdf

  - Mike P. Wittie, Veljko Pejovic, Lara Deek, Kevin C. Almeroth, Ben Y. Zhao **"Exploiting Locality of Interest in Online Social Networks"** ACM CoNEXT'10 www.cs.bham.ac.uk/~pejovicv/docs/Wittie10conext.pdf

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Thank you!

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