An Architecture for Internet Data Transfer

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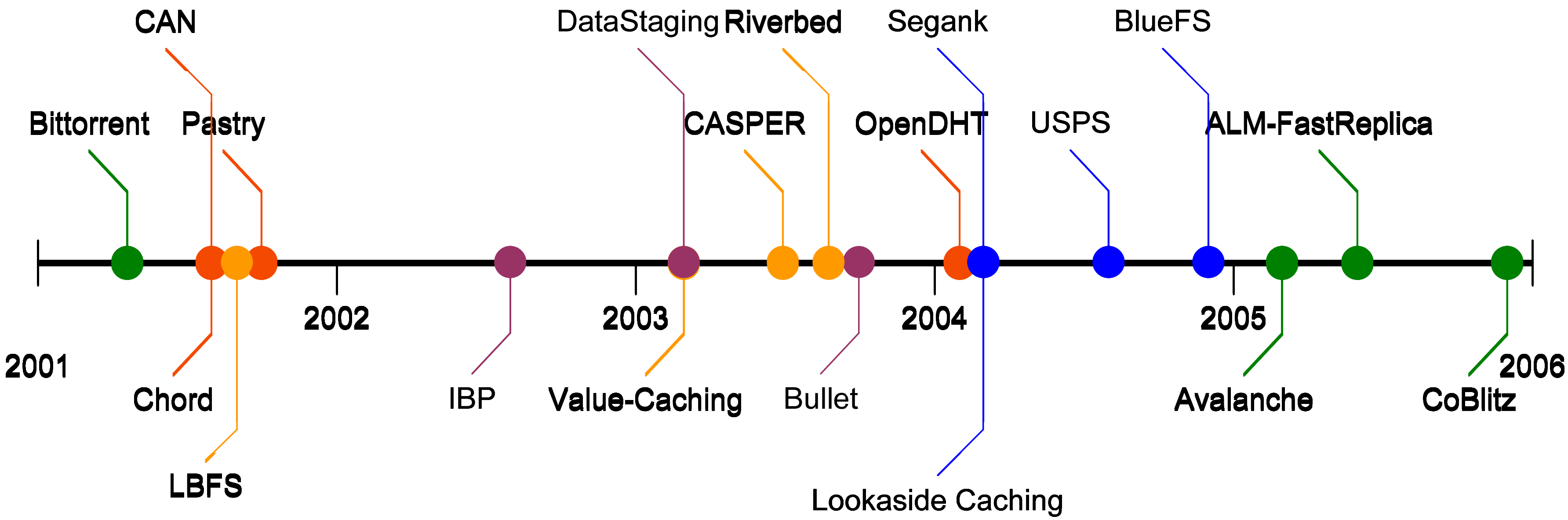
Innovation in Data Transfer is Hard

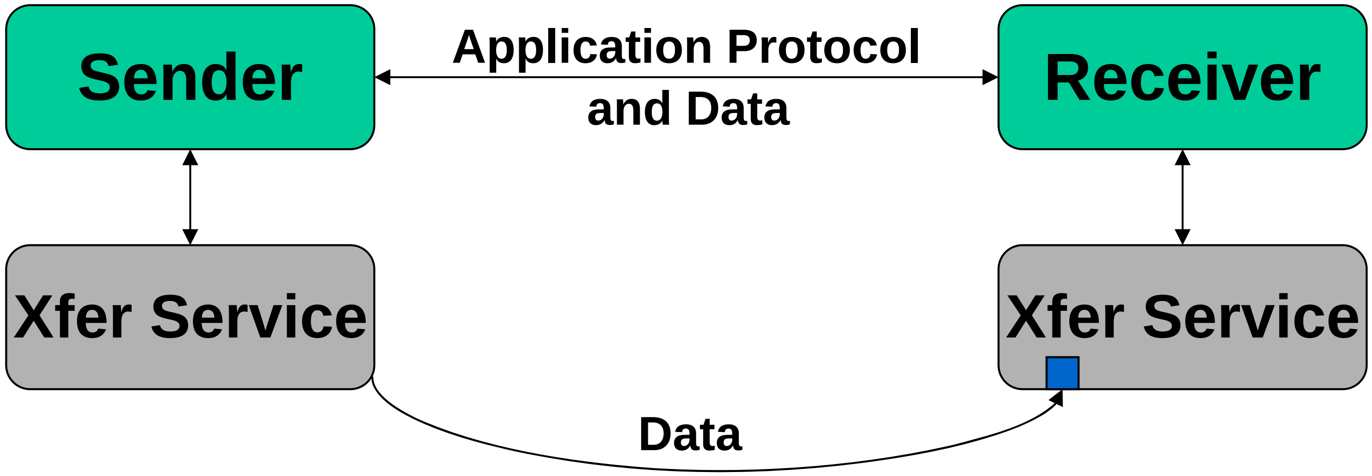


- Imagine: You have a novel data transfer technique
- How do you deploy?
  1. Update HTTP. Talk to IETF. Modify Apache, IIS, Firefox, Netscape, Opera, IE, Lynx, Wget, …
  2. Update SMTP. Talk to IETF. Modify Sendmail, Postfix, Outlook…
  3. Give up in frustration

Barriers to Innovation in Data Transfer

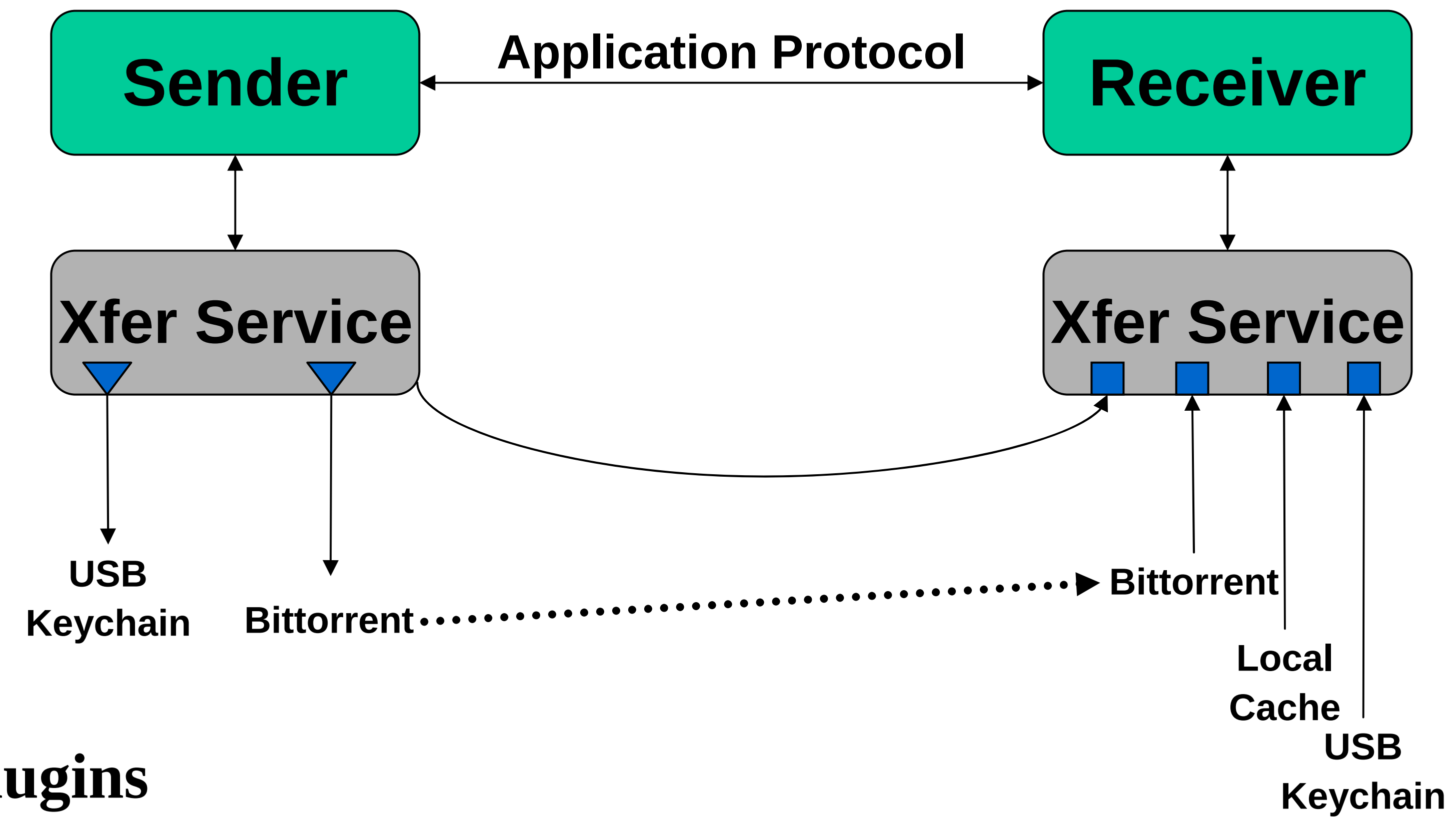
- Applications bundle:
  - **Content Negotiation**: What data to send
    - Naming (URLs, directories, …)
    - Languages
    - Identification
    - …
  - **Data Transfer**: Getting the bits across
- Both are tightly coupled (e.g., HTTP, SMTP)
- Hinders innovation and evolution of new services

Solution: A Data Transfer Service



- **Decouple content negotiation from data transfer**
- Applications perform negotiation as before
- But hand data objects to the Transfer Service
  - The Transfer Service is shared by applications

Extensible Transfer Architecture



Plugins

- ✓ Application-independent cache
- ✓ New network features
- ✓ Non-networked transfers

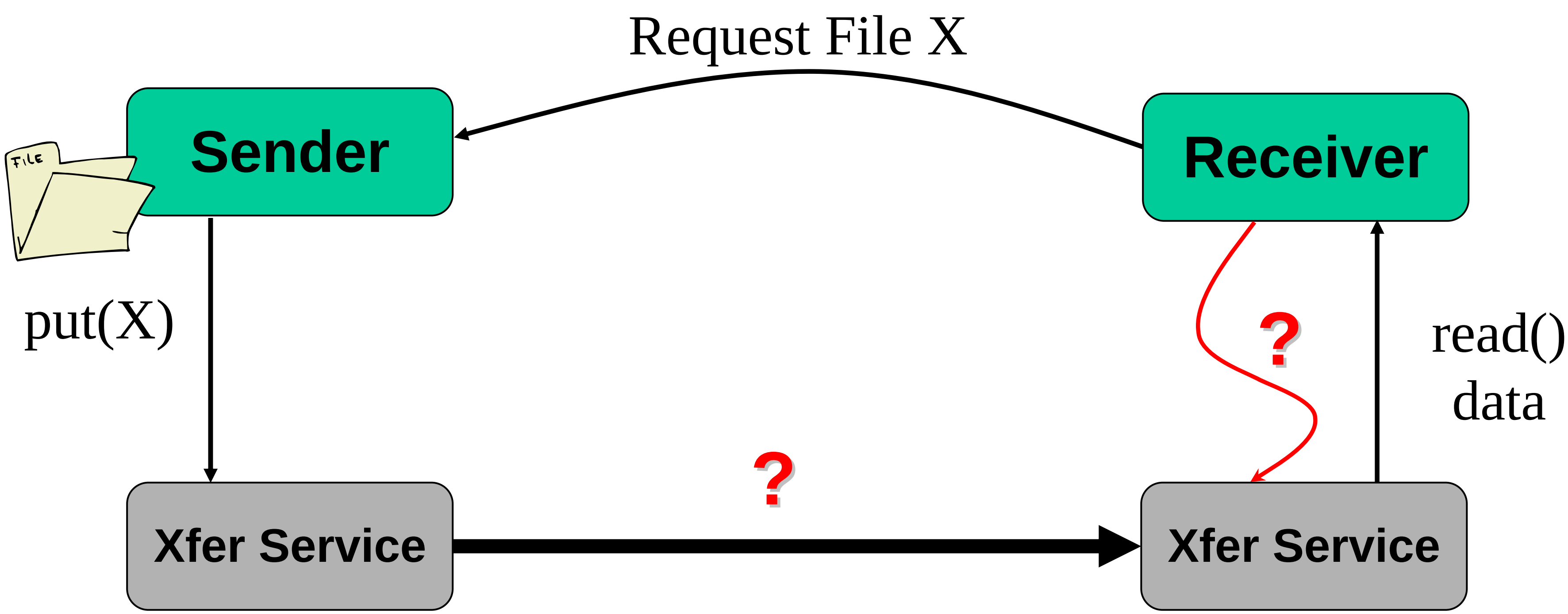
Transfer Service Benefits

- ✓ Apps. can reuse available transfer techniques
  - No reimplementation needed
- ✓ Easier deployment of new technologies
  - Applications need no modification
- ✓ Provides for cross-application sharing
  - Can interpose on all data transfers
- ✓ Handles transient disconnections

Outline

- *Motivation*
- Data Oriented Transfer (DOT) service
- Evaluation
- Open Issues and Future Work
- Conclusion

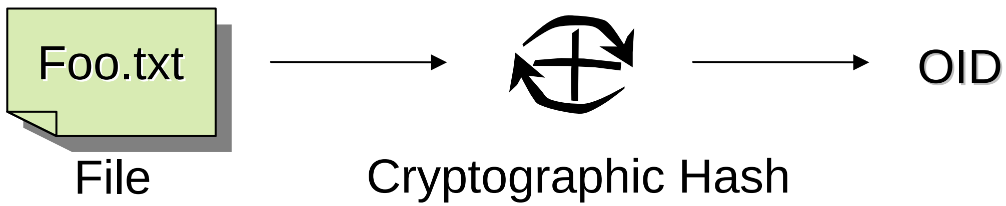
10,000 Foot View of Transfers using DOT



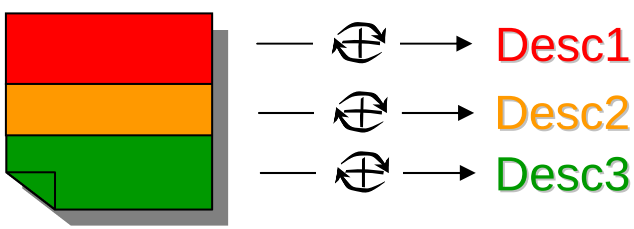
- How does the transfer service name data?
- How does the transfer service locate data?

DOT: Object Naming

- Application defined names are not portable
- Use content-naming for globally unique names
- Objects represented by an OID



- Objects are further sub-divided into “chunks”



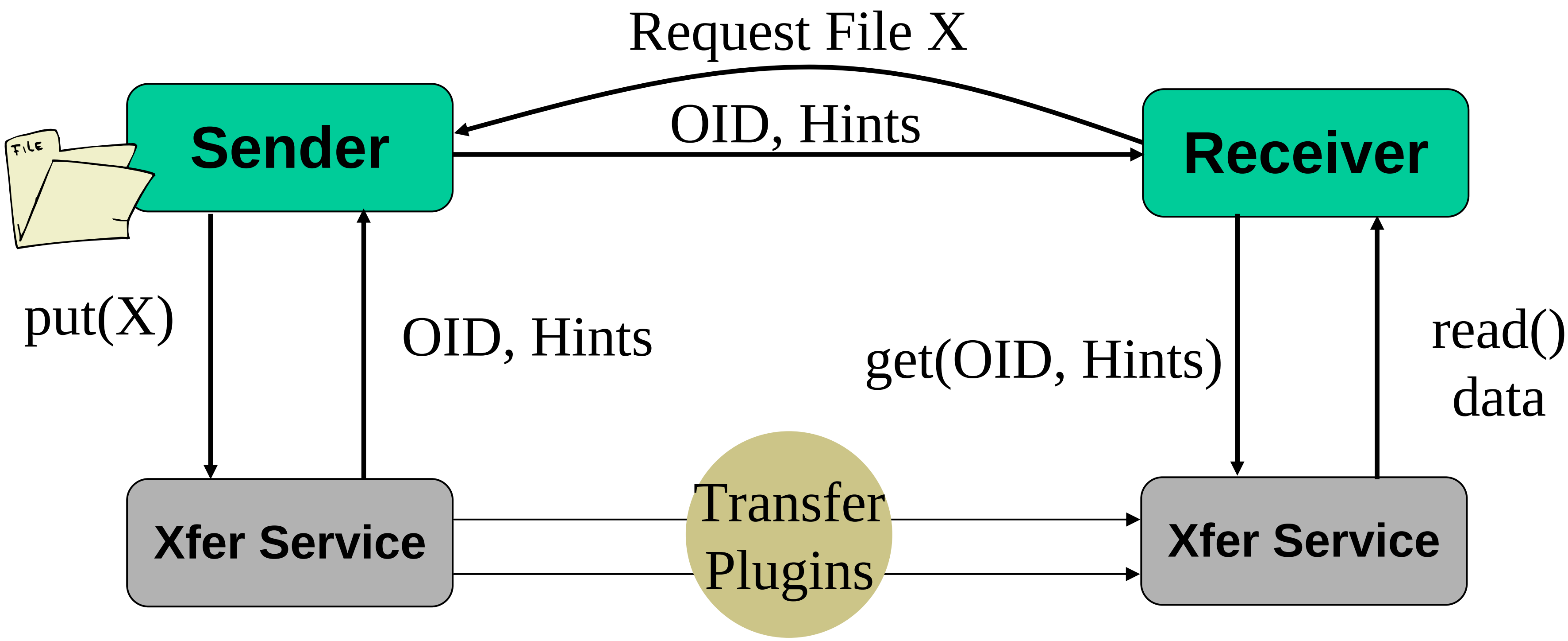
  - Each OID corresponds to a list of descriptors
  - Descriptor lists allow for partial transfers

DOT: Object Location

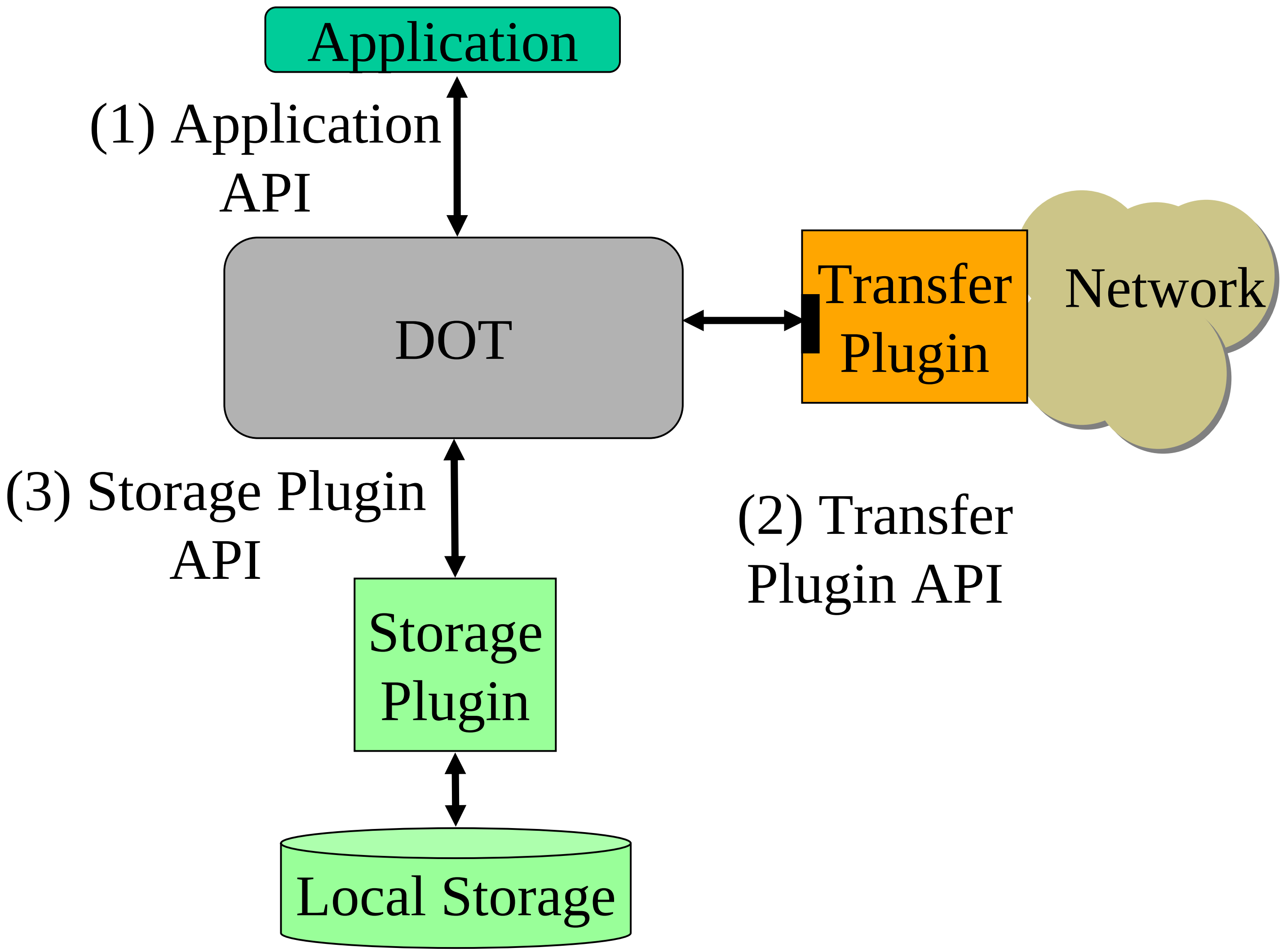
- Data transfers in DOT are receiver driven
  - Receiver has better idea of available resources

- Senders specify ‘hints’ - potential data locations
  - dot://sender.example.com:12000/
  - dht://opendht.org/
  - …

A Transfer using DOT



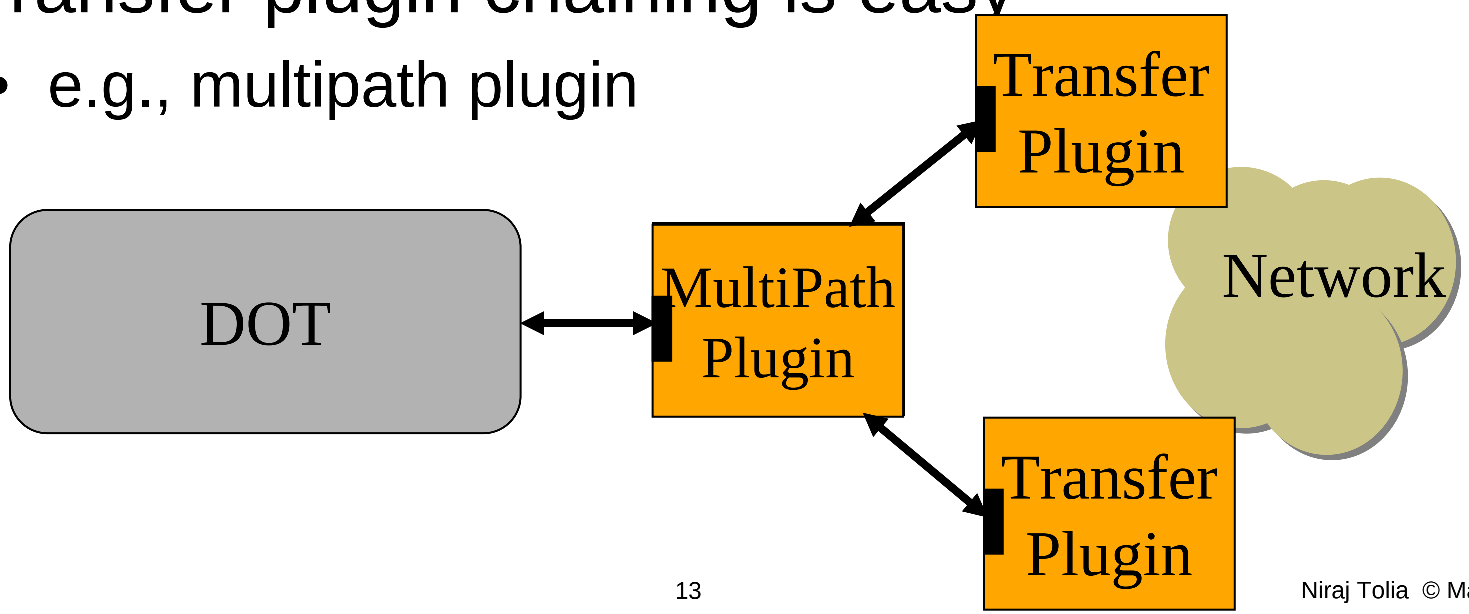
DOT's Modular Architecture



Transfer Plugin API

- Simple API
  - get_descriptor_list(OID, hints)
  - get_chunks(descriptor_list, hints)
  - cancel_chunks(chunk_list)

- Transfer plugin chaining is easy
  - e.g., multipath plugin

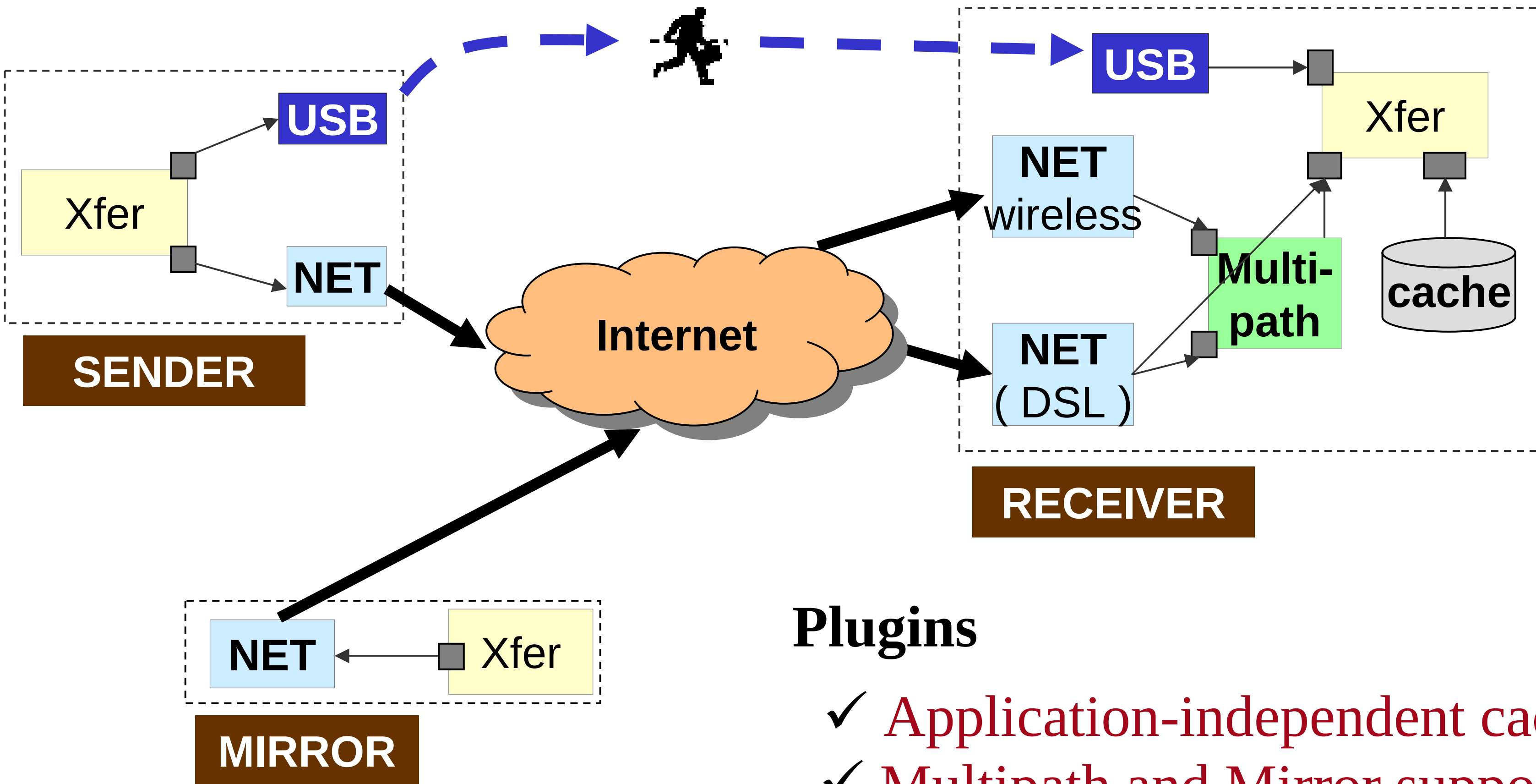


Implementation

- In C++ using *libasync* event-driven library
- One storage plugin:
    - – In-memory hash tables, disk backed.
- Three transfer plugins:
    - Default Xfer-Xfer plugin
    - Portable Storage plugin
    - Multipath plugin

- Applications
    - gcp, an scp-like tool for file transfers
    - A DOT-enabled Postfix email server
        - – Included a socket-like adapter library

Current DOT Prototype



Plugins

- ✓ Application-independent cache
- ✓ Multipath and Mirror support
- ✓ Non-networked transfers

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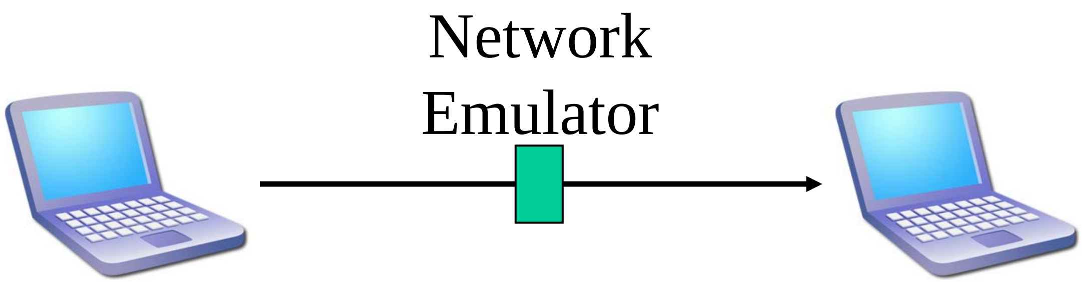
Evaluation

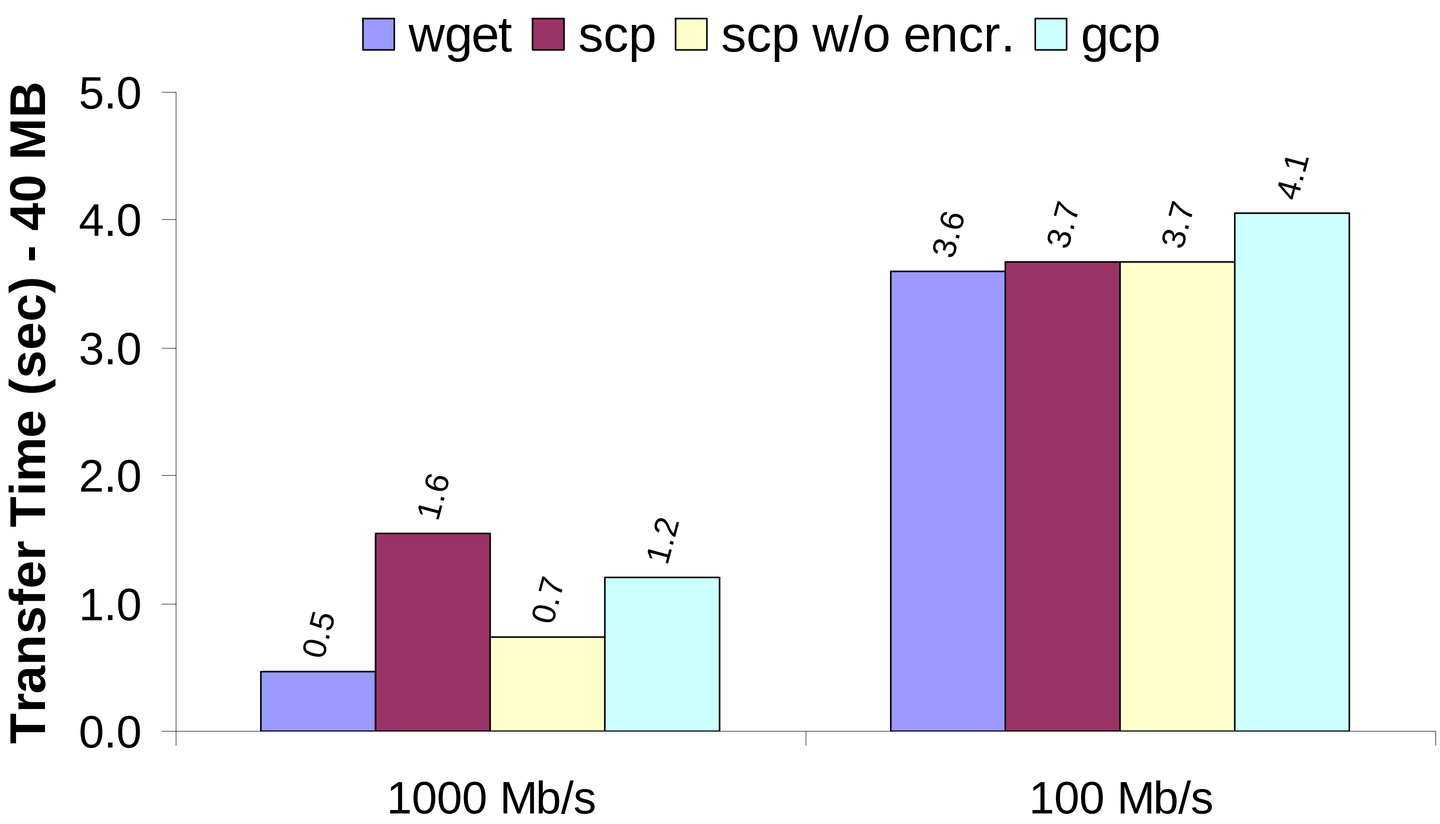
- Standard file transfer
- Portable Storage
- Multi-Path
- Case Study: Postfix Email Server
  - *Capture and analysis of email trace*
  - Evaluation of DOT-enabled SMTP server
  - Integration effort

Standard File Transfer Setup



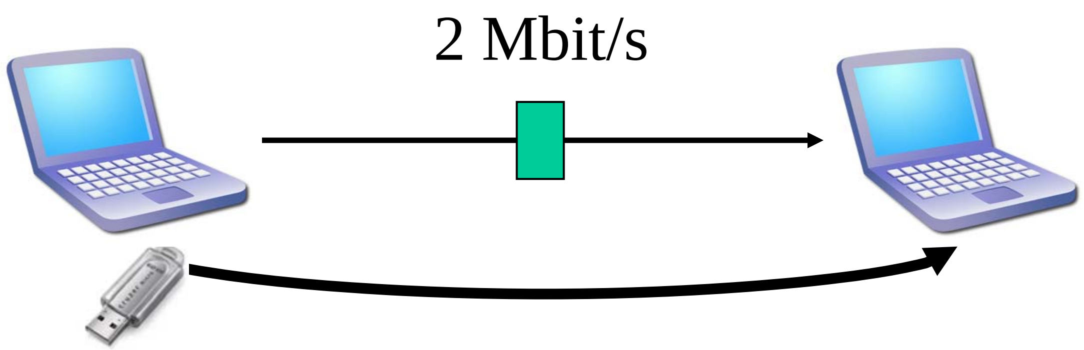
- Two DOT-enabled machines
- Network Emulator
  - Evaluate various b/w + delay combinations
- Use ***gcp*** for the file transfers
- Used 40MB, 4MB, 400KB, 40KB, 4KB files
  - Presenting 40MB here

Standard File Transfer



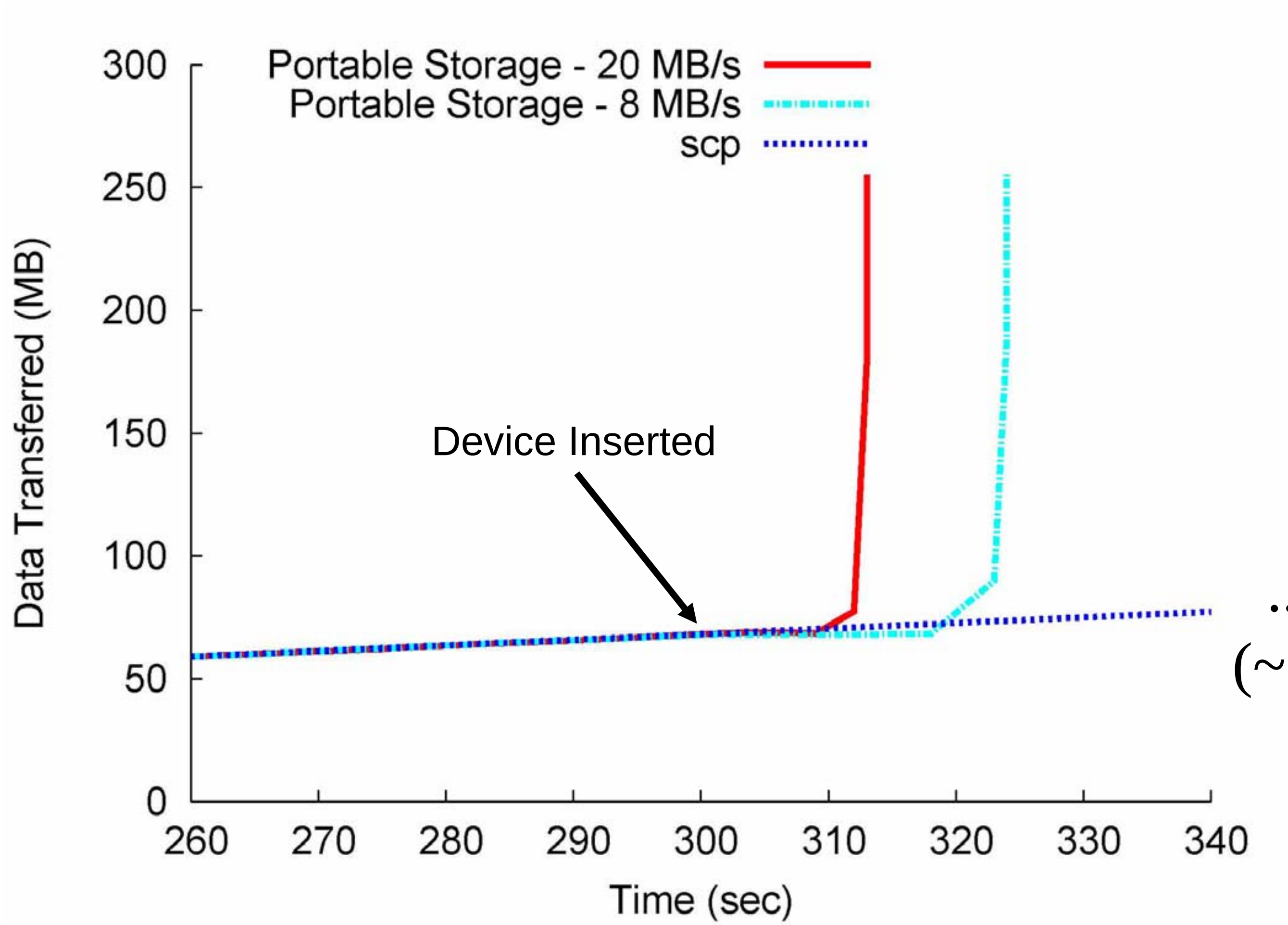
- Overhead: hashing, extra RTT
- No noticeable overheads with latency

Portable Storage Experiment



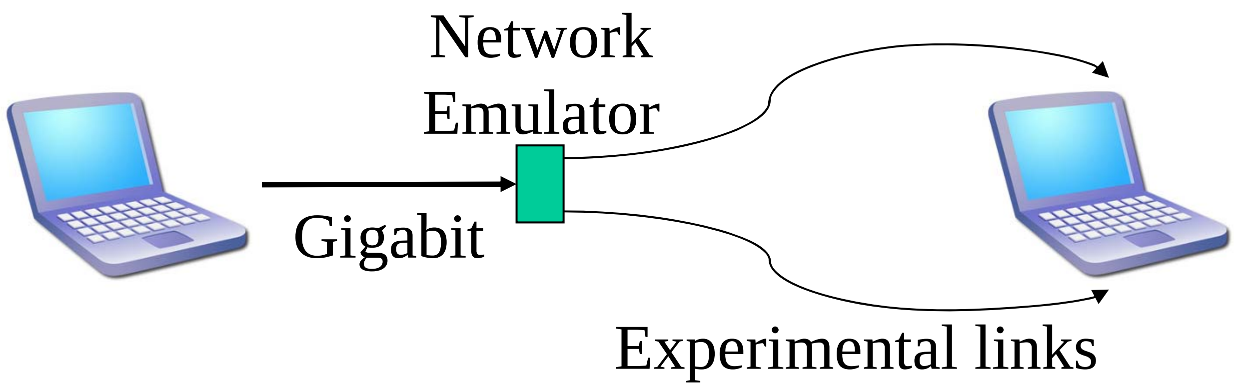
- 255 MB transfer over emulated DSL
  - Based on Virtual Machine transfers at Carnegie Mellon
  - DOT preemptively copies data onto Flash drive
- Wait 5 minutes, plug flash drive into receiver
- Two drive speeds
  - 8MB/s - 1GB
  - 20MB/s - 2GB

Portable Storage Results



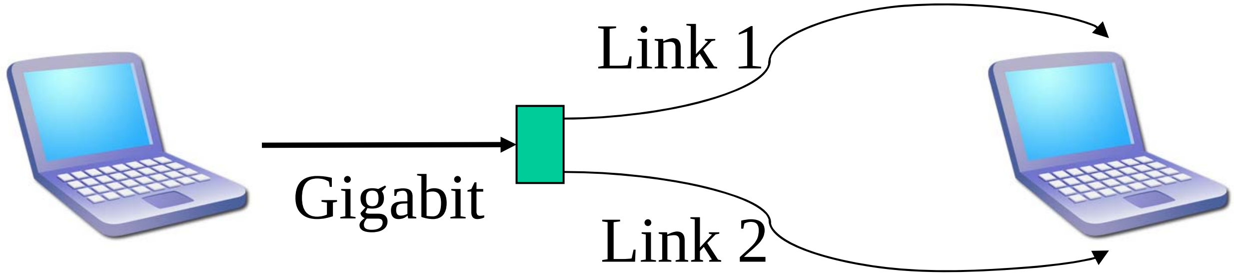
.. 1126s
(~ 19 min)

Multipath Plugin: Load Balancing



- Varied capacity + delay of experimental links
  - Compare fastest link alone with multipath plugin on both links; what speedup?
- Transferred 40MB file
  - 128 KB socket buffer sizes

Multipath Plugin is Effective



Link 1	Link 2	Single	Multipath	Savings
100/0	100/0 10/0	3.59	1.90 3.54	47% 1.4%

-40 MB @ 100Mbit/s ideal: 3.2 seconds

-Multipath plugin nearly doubles throughput

- TCP effects dominate. Pipe not full.

- Multipath plugin doubles by adding second stream. Actual capacity irrelevant.

Postfix Email Trace Replay

- Generated 10,000 email messages from trace
  - Random data matched to chunk hash data
  - Preserves *some* similarity between messages
  - Replayed through Postfix to a single local server

Program	Seconds	Bytes Sent
Postfix	468	172 MB
Postfix + DOT	468	117 MB (68%)

  - Postfix disk bound… DOT CPU overhead negligible
  - Savings due to duplication within emails

Postfix Integration

- Integrated DOT with the Postfix mail server

Program	LoC	Added LoC	%
GTC Lib	--	421	
Postfix	70,824	184	0.3%
smtpd	6,413	107	1.7%
smtp	3,378	71	2.1%

- 1 part-time week, 1 student new to Postfix
  - Includes time to write generic adapter library

Discussion on Deployment

- Application Resilience
  - DOT is a service - it's outside the control of the application.
  - Our Postfix falls back to normal SMTP if
    - No Transfer Service contact
    - Transfer keeps failing
  - In the short term, a simple fallback is encouraged. However, this could interfere with some functions
    - DOT-based virus scanner…
  - In the long term, DOT would be a part of a system's core infrastructure

Future Work

- Security
  - Application encrypts before DOT
    - No block-based caching, reuse, mirroring, …
  - No encryption
    - Resembles the status quo
  - In progress: Convergent encryption
    - Requires integration with DOT chunking
- Application Preferences
  - Encryption, QoS, priorities, …
    - DOT might benefit from application input
  - Need an extensible way to express these

Conclusion

- DOT separates app. logic from data transfer
  - Makes it easier to extend both
- Architecture works well
  - Overhead low (especially in wide-area)
  - Major benefits
    - Caching
    - Flexibility to implement new transfer techniques
- Source code available on request

http://www.cs.cmu.edu/~dga/dot/