

# ALL-IN-ONE STREAMS FOR CONTENT CENTRIC NETWORKS

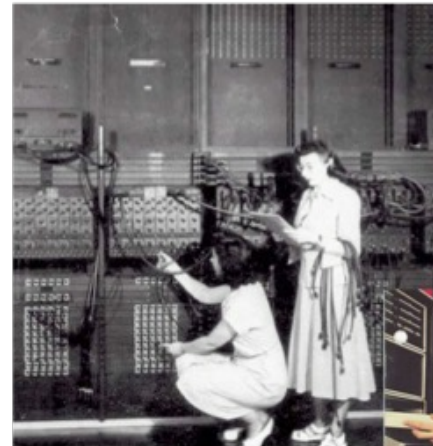
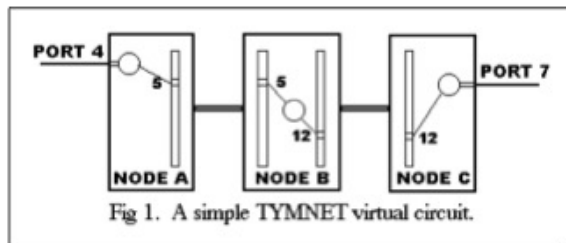


Marc Mosko, Palo Alto Research Center (PARC)

CONNET 2015

The International Symposium on Advances in Content-oriented Networks and Systems

# Computer networks started as wires or virtual wires



## We've lowered the cost of the world.

No, the low CompuServe \$5.00 per hour charge hasn't changed, but the world of information we offer is growing steadily.



**1984-85 Color Computer and Videotext**  
The CompuServe Information Service is sold in Radio Shack® Stores and, in addition to all the major brands of computers and terminals, can be used with the new 1984-85 Color Computer and Videotext terminal. Our special software formats the information in easy-to-read pages. Go forward, backward, anywhere in the CompuServe Information Service databases—often directly to a page of information.

**More Computer Power!**  
The number of CompuServe customers keeps growing—now more than 6,000 strong. The more customers we have, the more computer power and access lines we dedicate to our information service. Our 25 mainframe computer systems provide sufficient power and capacity to serve thousands more.

**More News**  
In addition to the Associated Press, we've added more news. Read The New York Times and all the news that's fit to print, including Broadway show and movie reviews, stories from Pulitzer Prize-winning

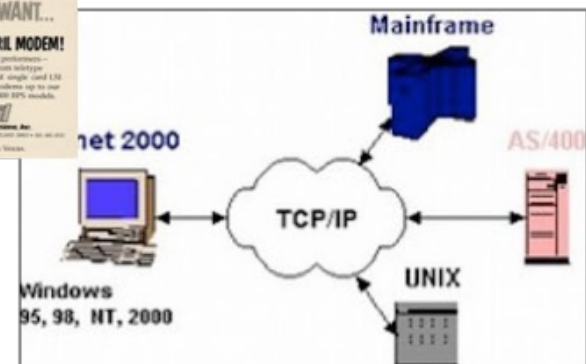
**Big System Reliability**  
When we say we're reliable, we mean it. In fact CompuServe computers were up and running for a 99.9 percent reliability factor last year. We've also built in many "failover" features like data error detection and retransmission—all those technical enhancements which add up to the CompuServe Information Service being ready to use when you're ready to use it.

**Not 1984, NOW!**  
See for yourself what a state-of-the-art electronic information service can do. Get a demonstration at a Radio Shack® computer center or store—or write to us for further information.

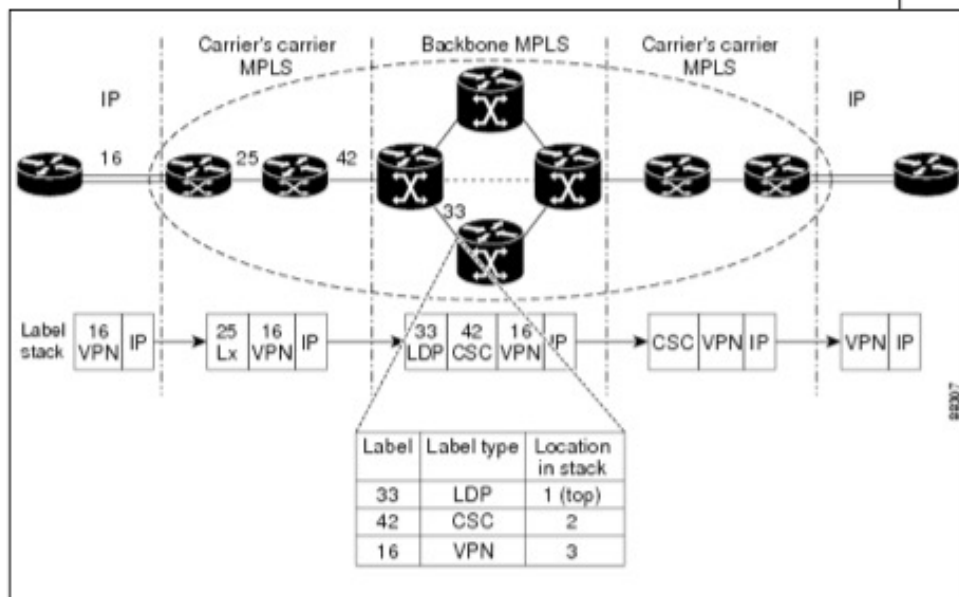
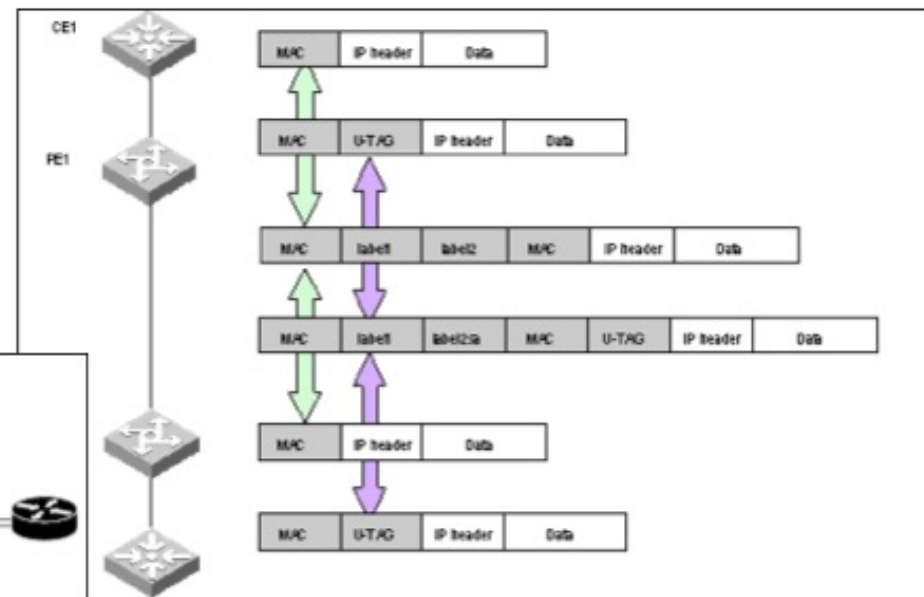
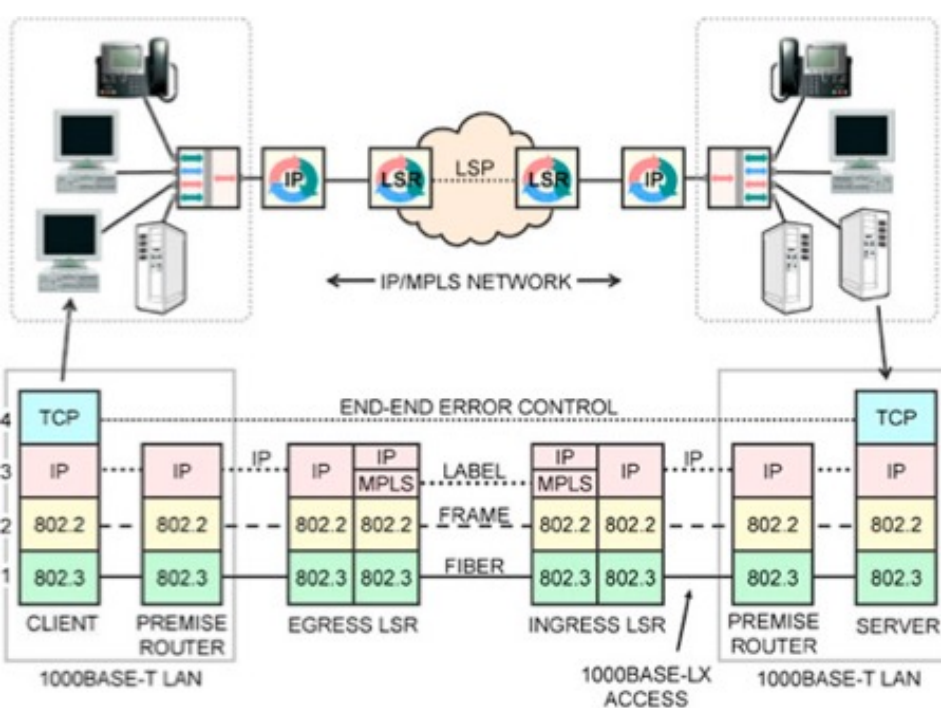


**CompuServe**

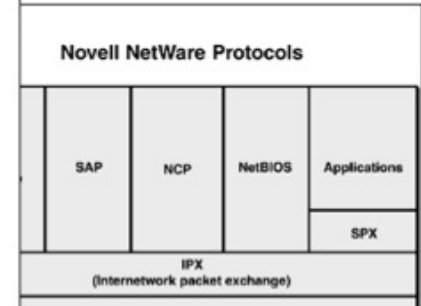
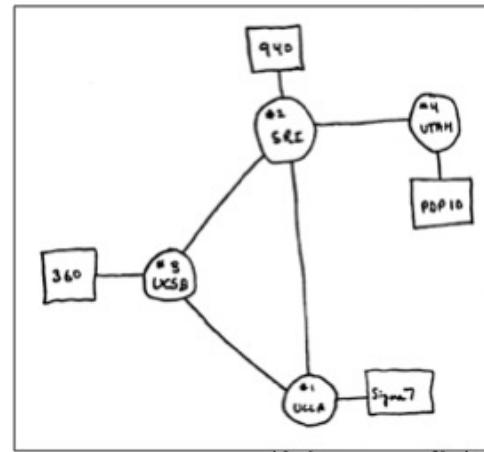
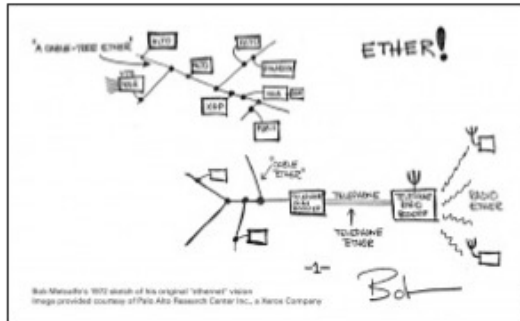
Information Service Division  
Electronic Data Systems Corp.  
Ann Arbor, MI 48106  
(313) 962-1000



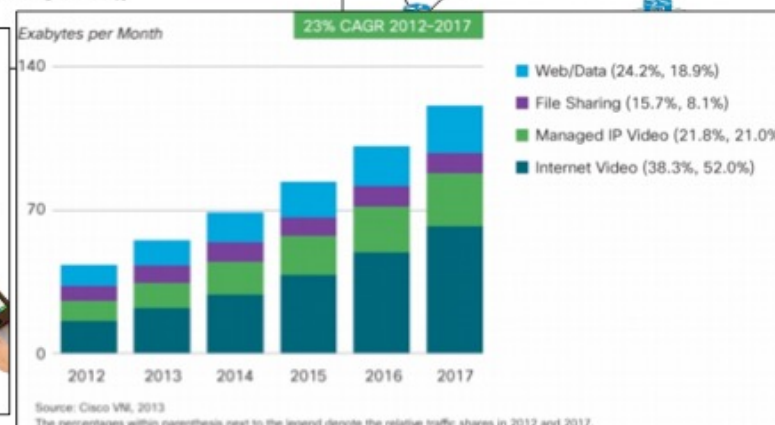
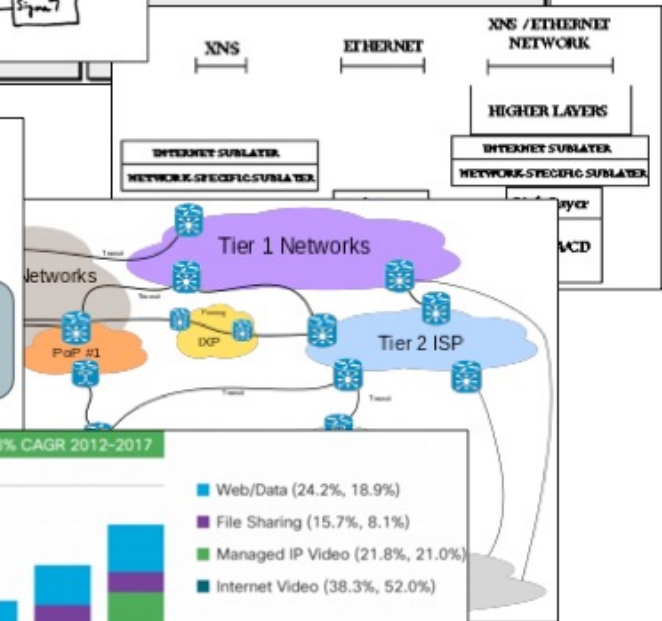
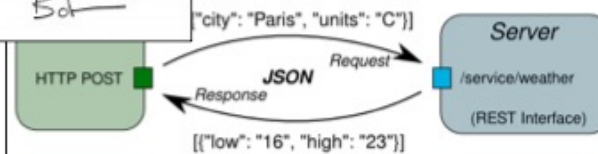




# Then evolved to distributing content



JSON / REST / HTTP



We no longer connect wires

We move content (information)

# INFORMATION CENTRIC NETWORKS

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Name the data

Transfer data based on the names

Break end-to-end paradigm

Ted Nelson's Project Xanadu (1979)

# CONTENT CENTRIC NETWORKS (CCNX)

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TRIAD (1999) / DONA (2006)

CCNx at PARC in 2007 (Van Jacobson)

CCNx 0.1 Software (2009-2013)

Named Data Networking Project (2010)

CCNx 1.0 (2012-present)

# HOW IT WORKS

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Application

**Ici:/com/xerox/parc/pubs/connet2015.pptx**

Service  
Frameworks

**Ici:/com/xerox/parc/pubs/connet2015.pptx,  
Publisher key = 0x184839a3eff90...**

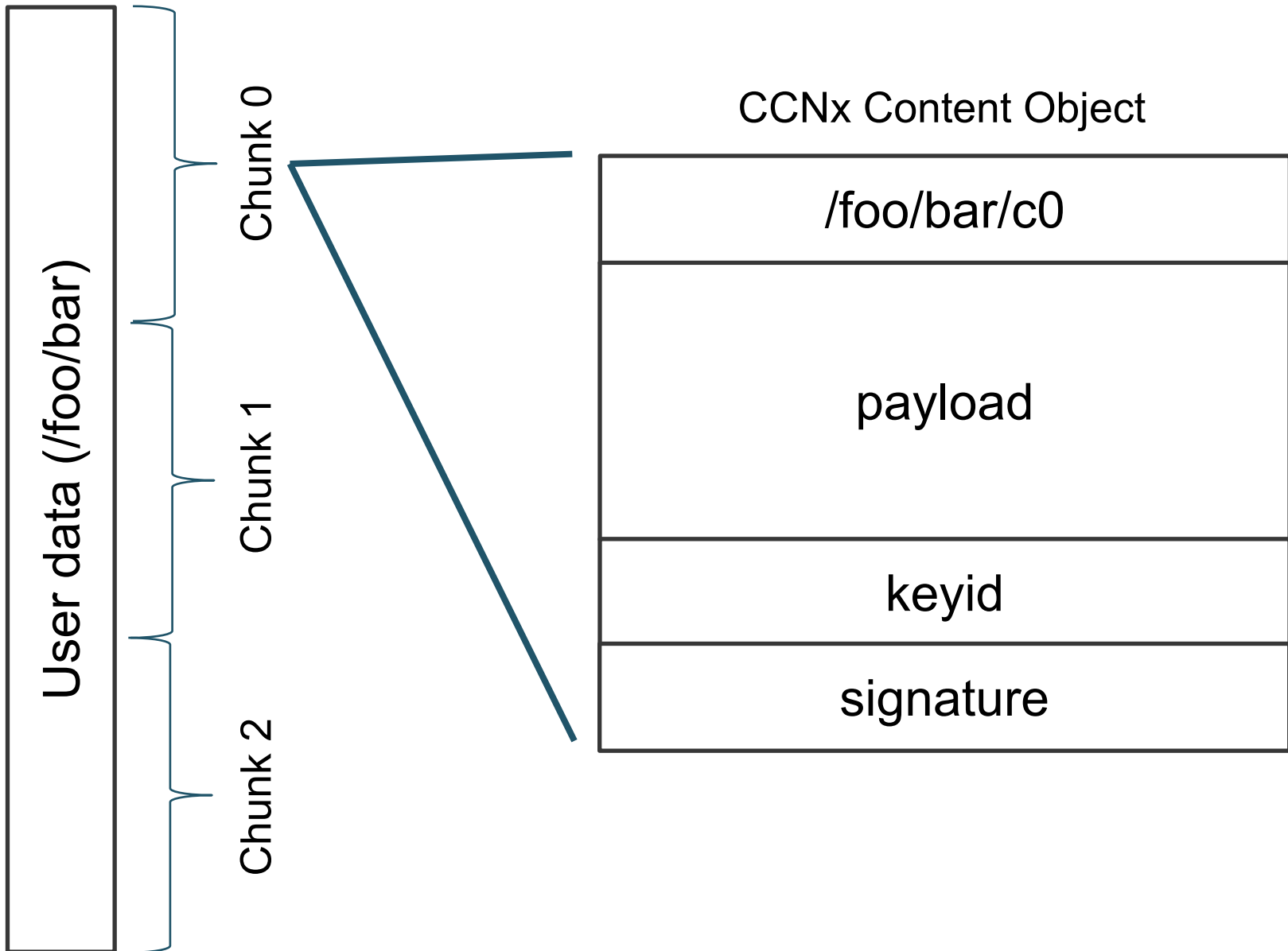
Transport

**Ici:/com/xerox/parc/pubs/connet2015.pptx,  
Publisher key = 0x184839a3eff90...  
Chunks = 0, 1, ...**

**Forwarder**

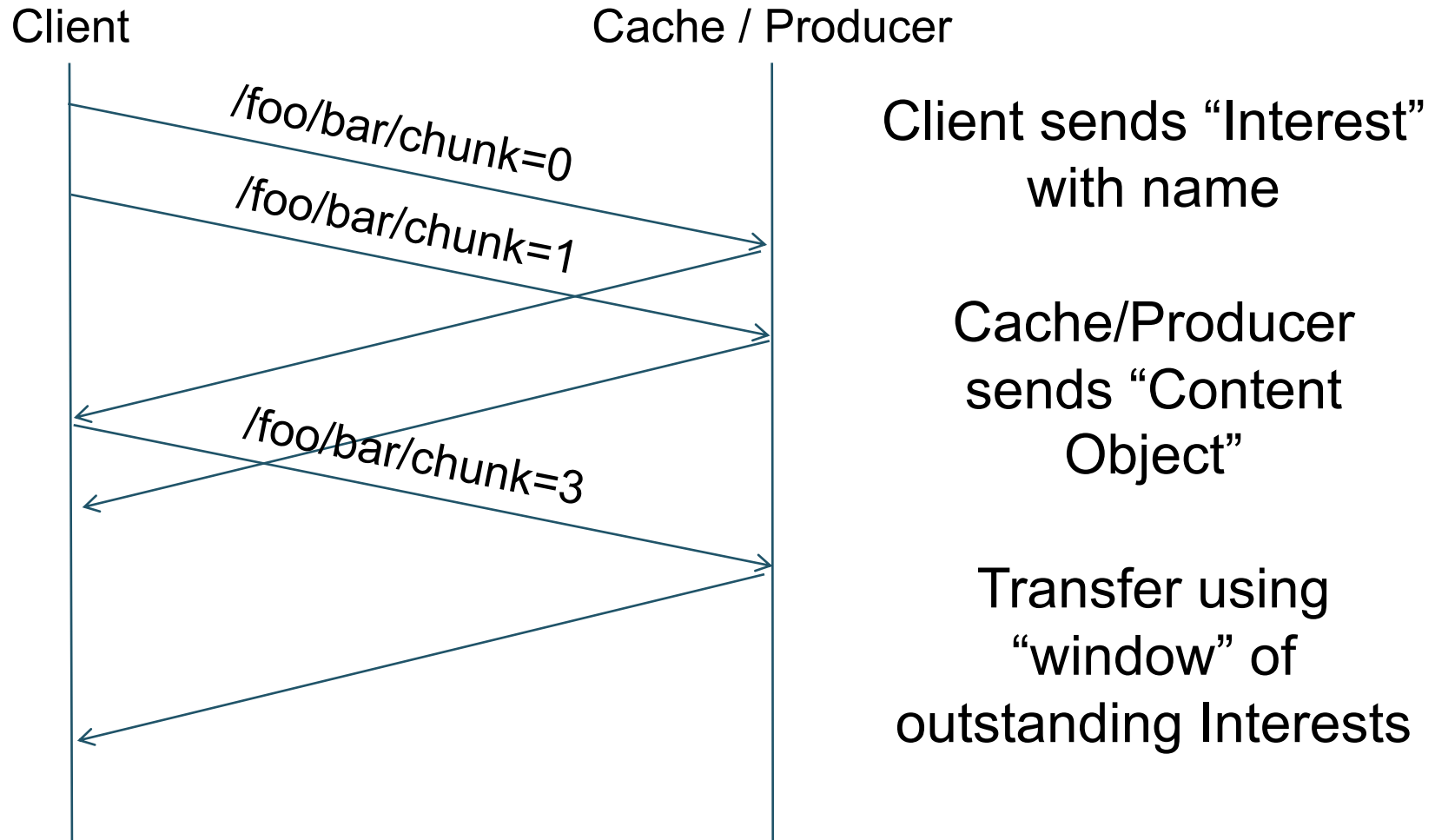
**Name Forwarding Table  
Pending Interest Table (reverse path)**



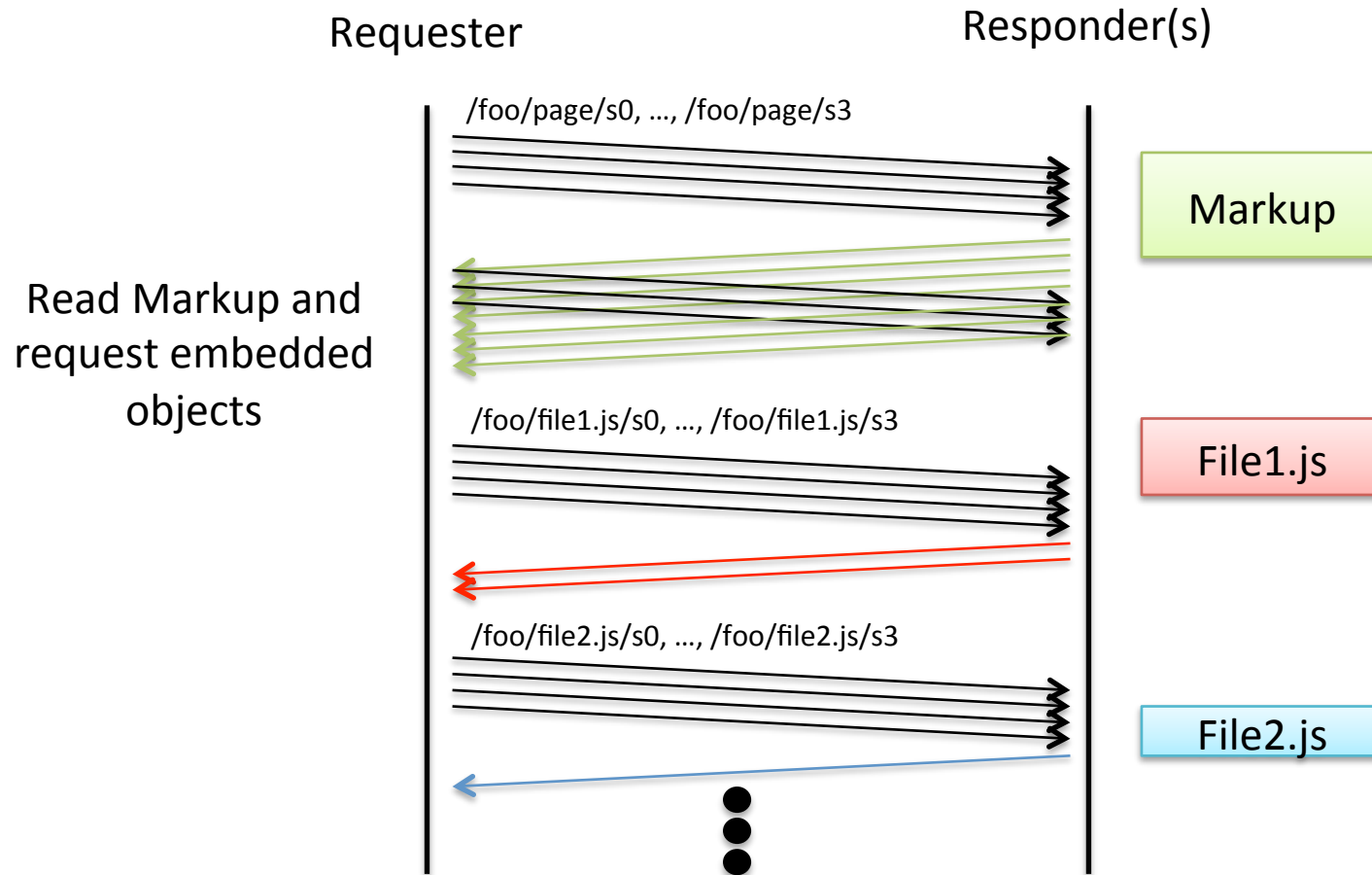


# REQUEST/RESPONSE PROTOCOL

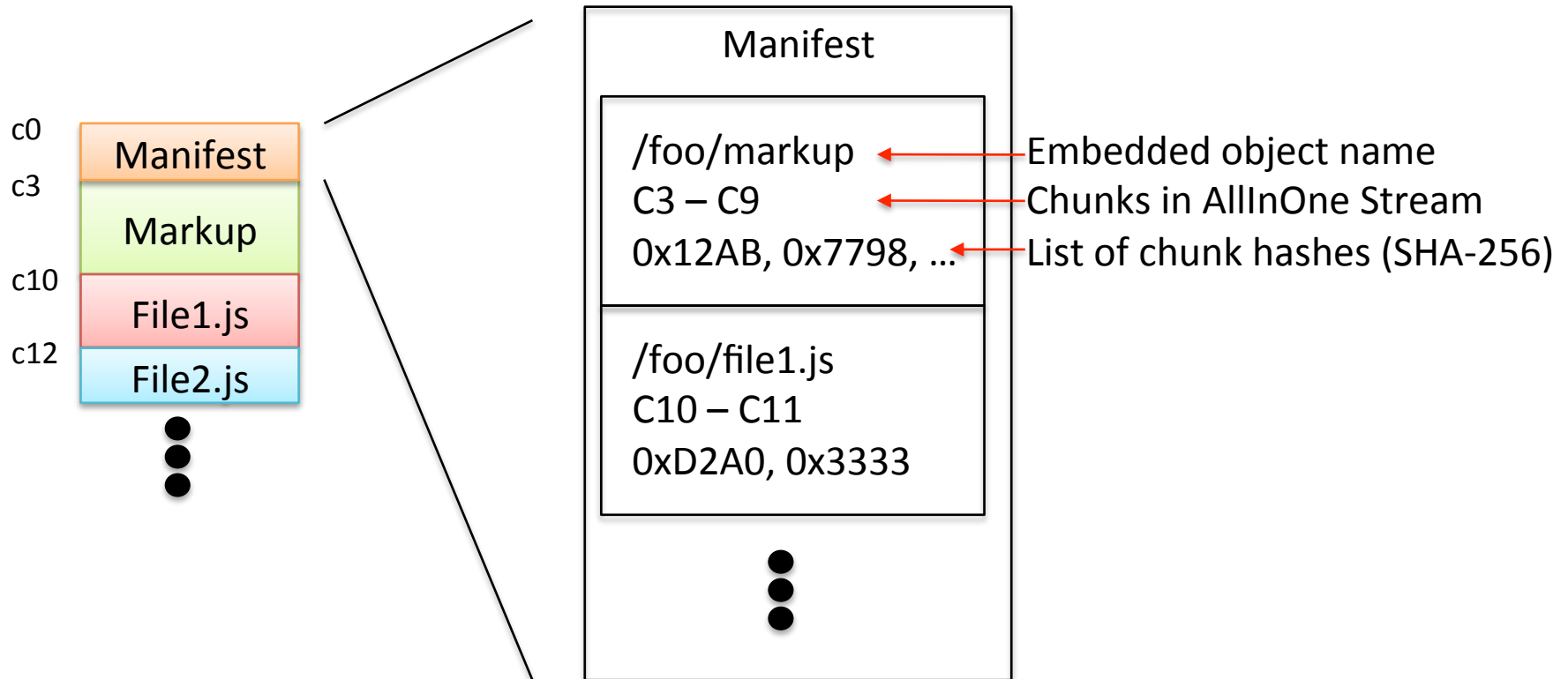
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# MULTIPLE WINDOW PROBLEMS

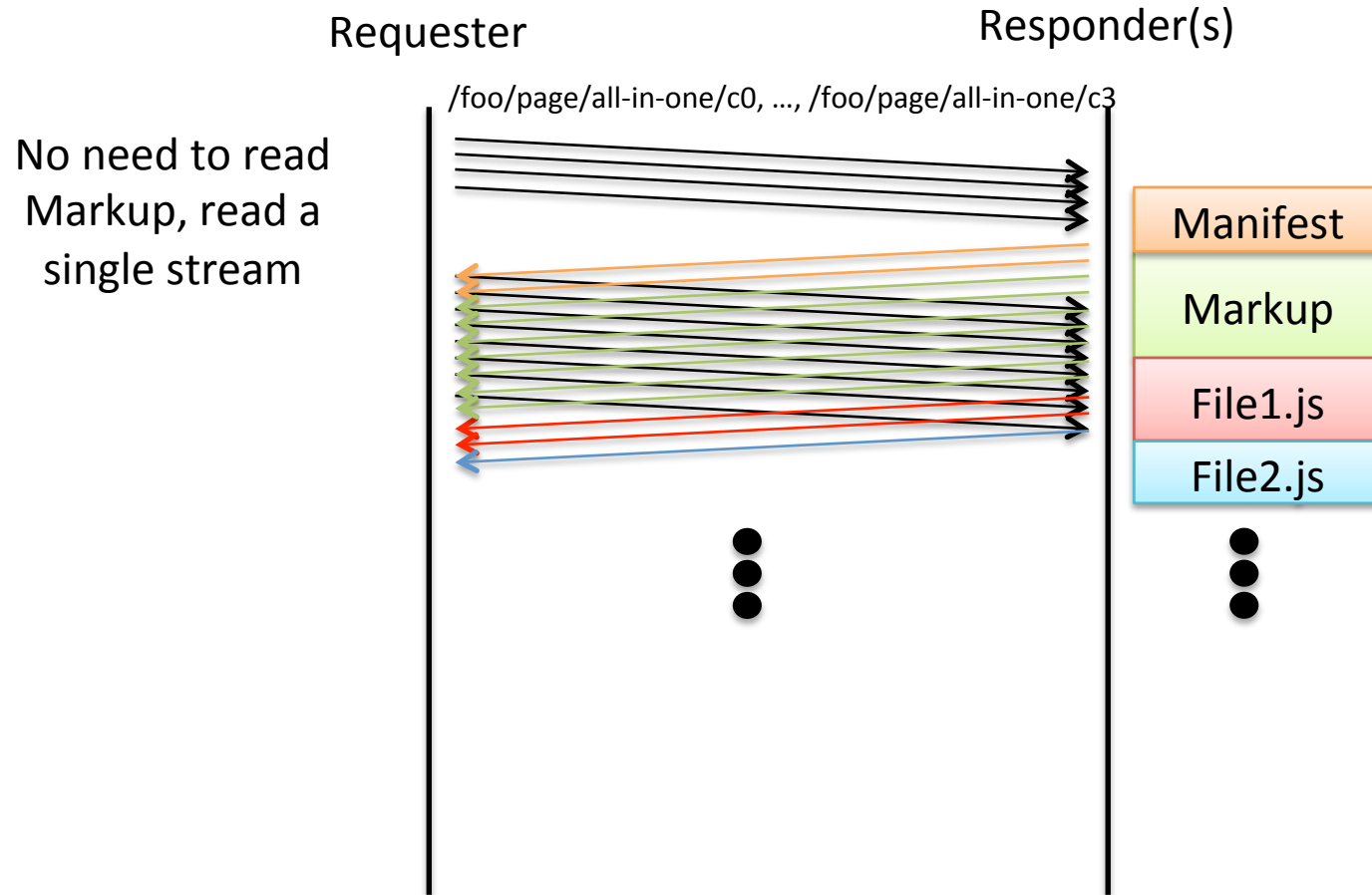


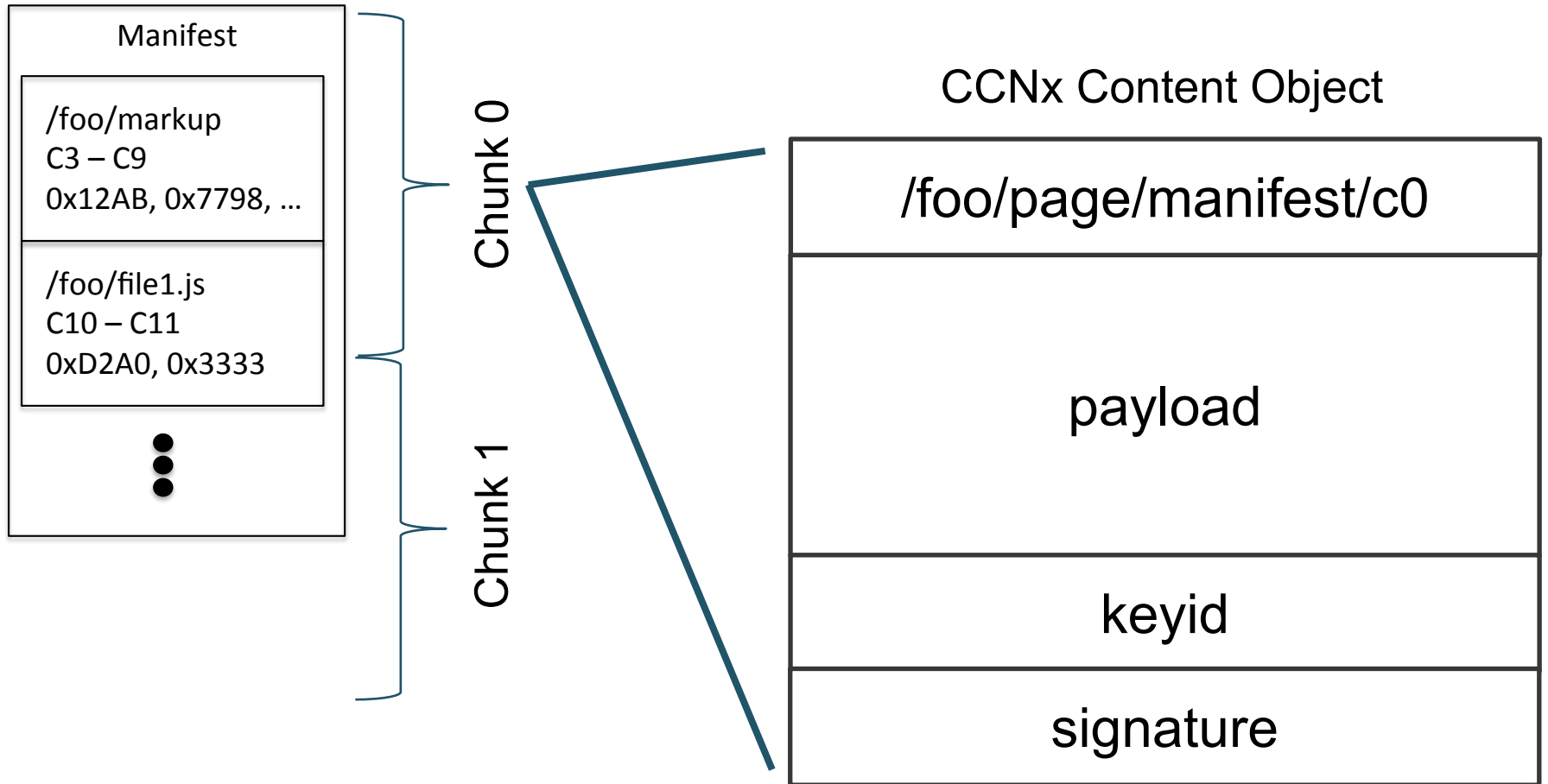
# COMBINE ALL OBJECTS TO ONE STREAM

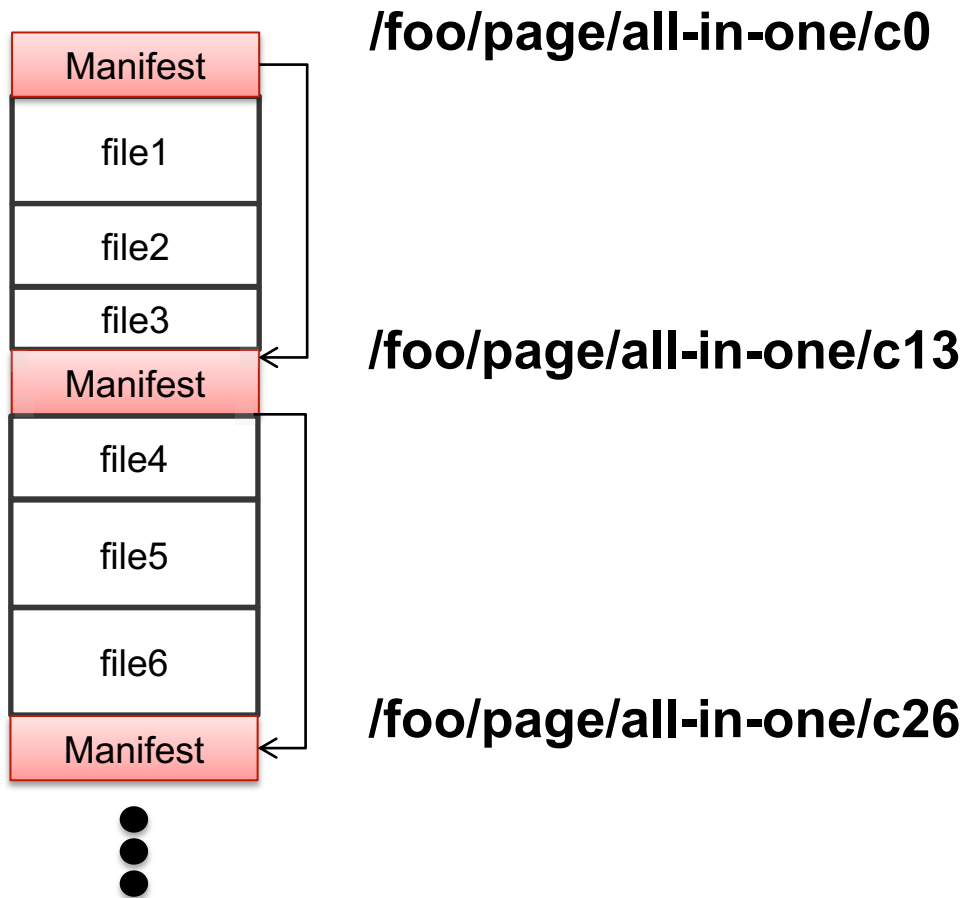




# SINGLE WINDOW FOR ALL OBJECTS

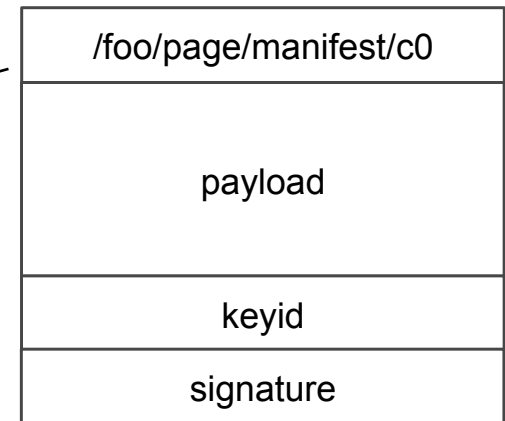
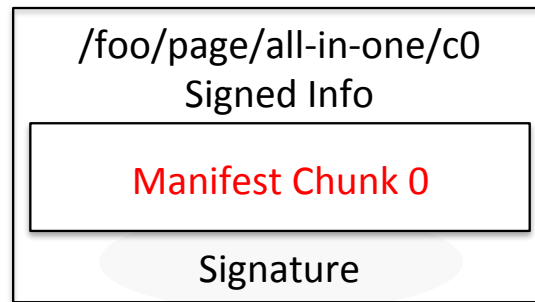




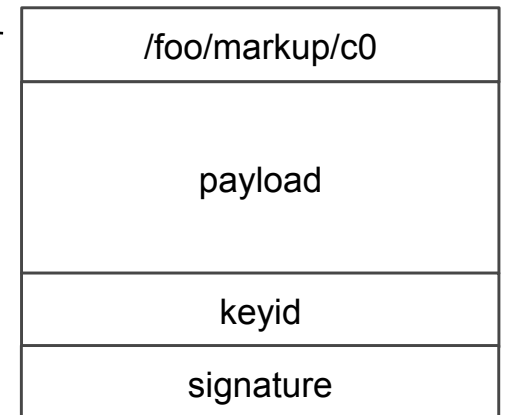
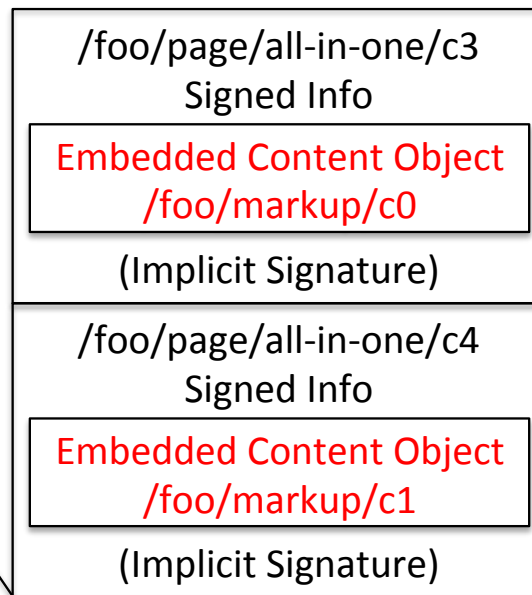


Allow chaining  
manifests

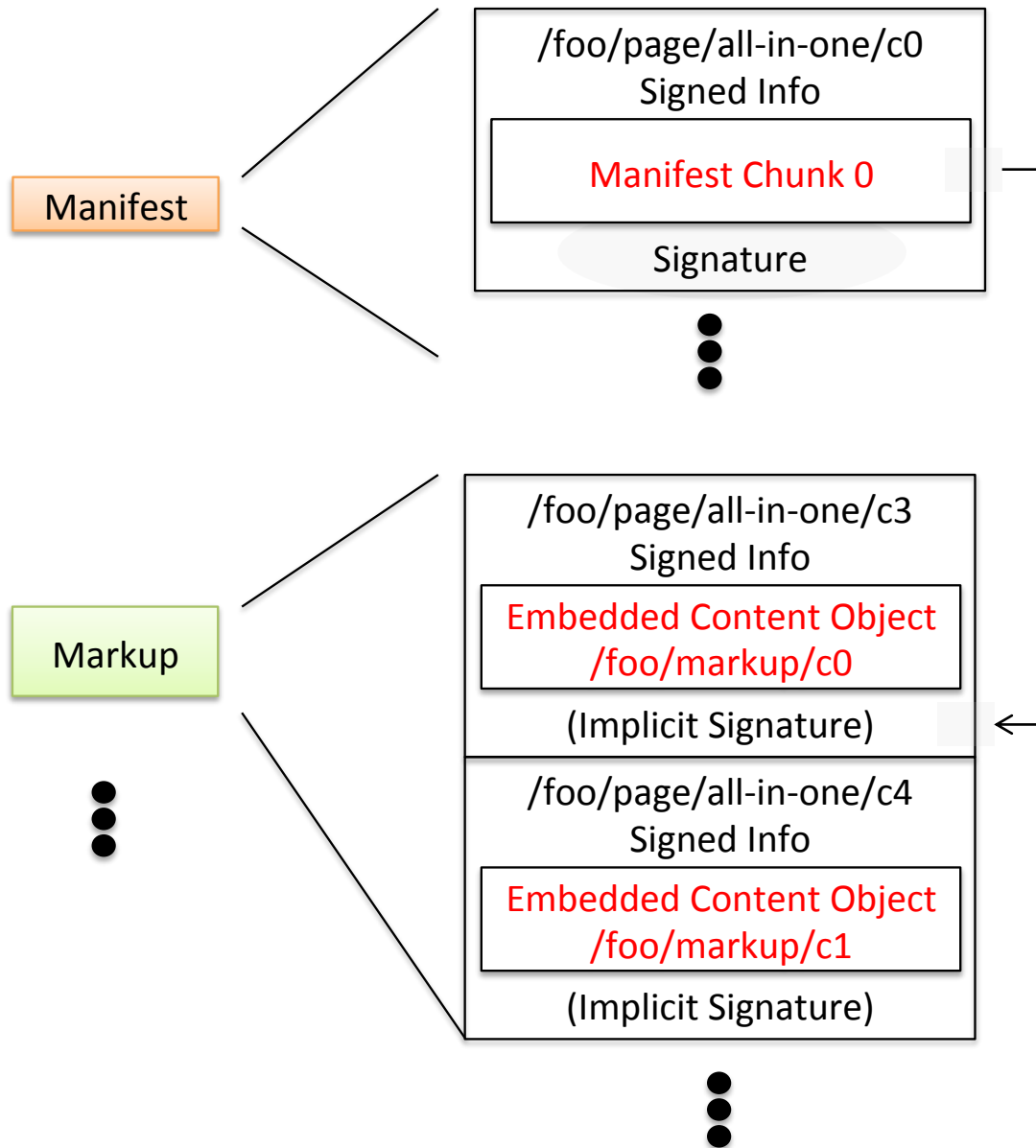
Manifest



Markup





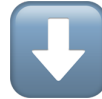


Implicit signature  
realized by hash  
chain from Manifest

# ENCAPSULATION

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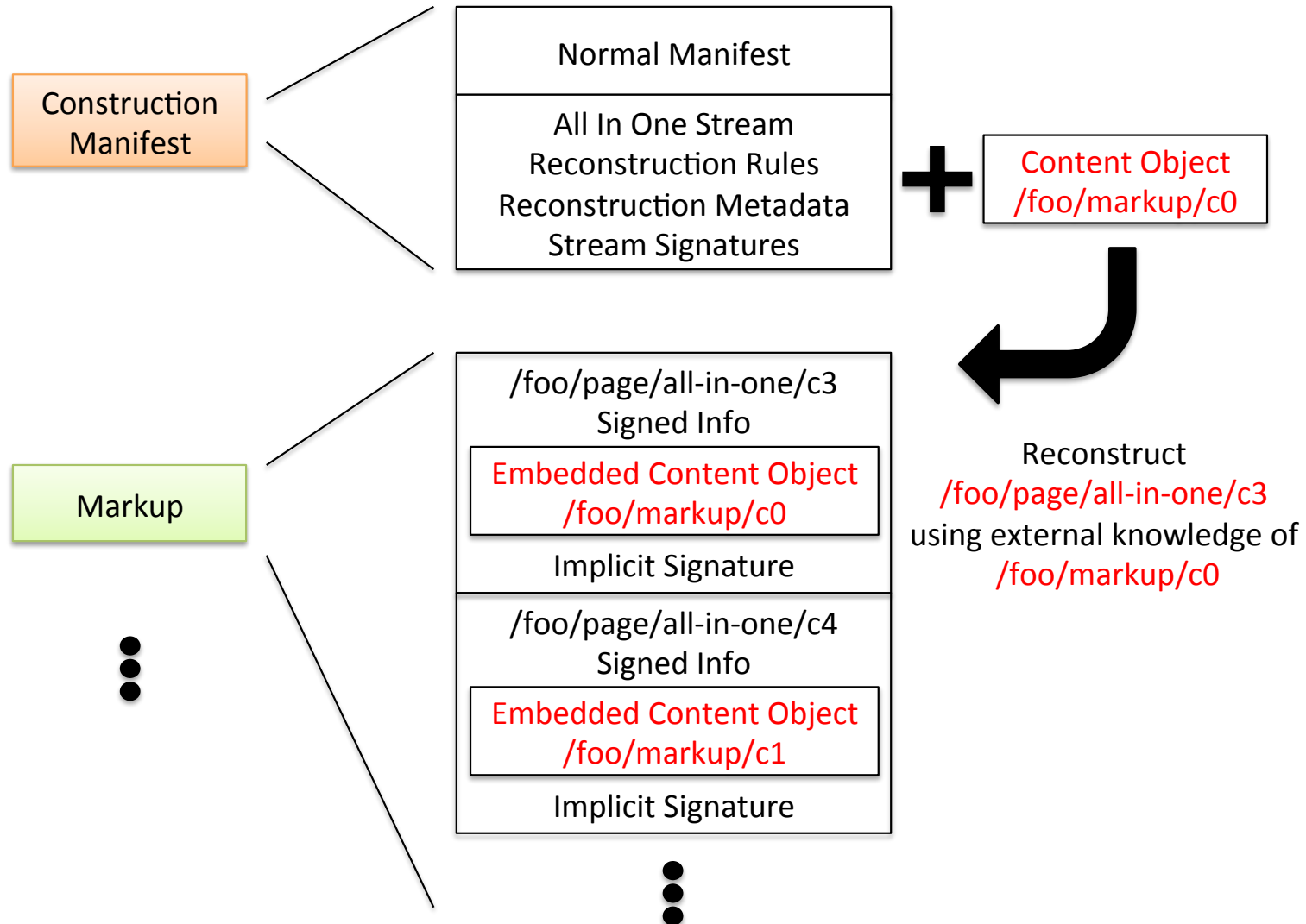
/foo/markup/c0



/foo/page/all-in-one/c3

What about caching?

# CACHING ORIGINAL OBJECTS





/foo/markup/c0

Client

cache

Producer





/foo/markup/c0

Client

cache

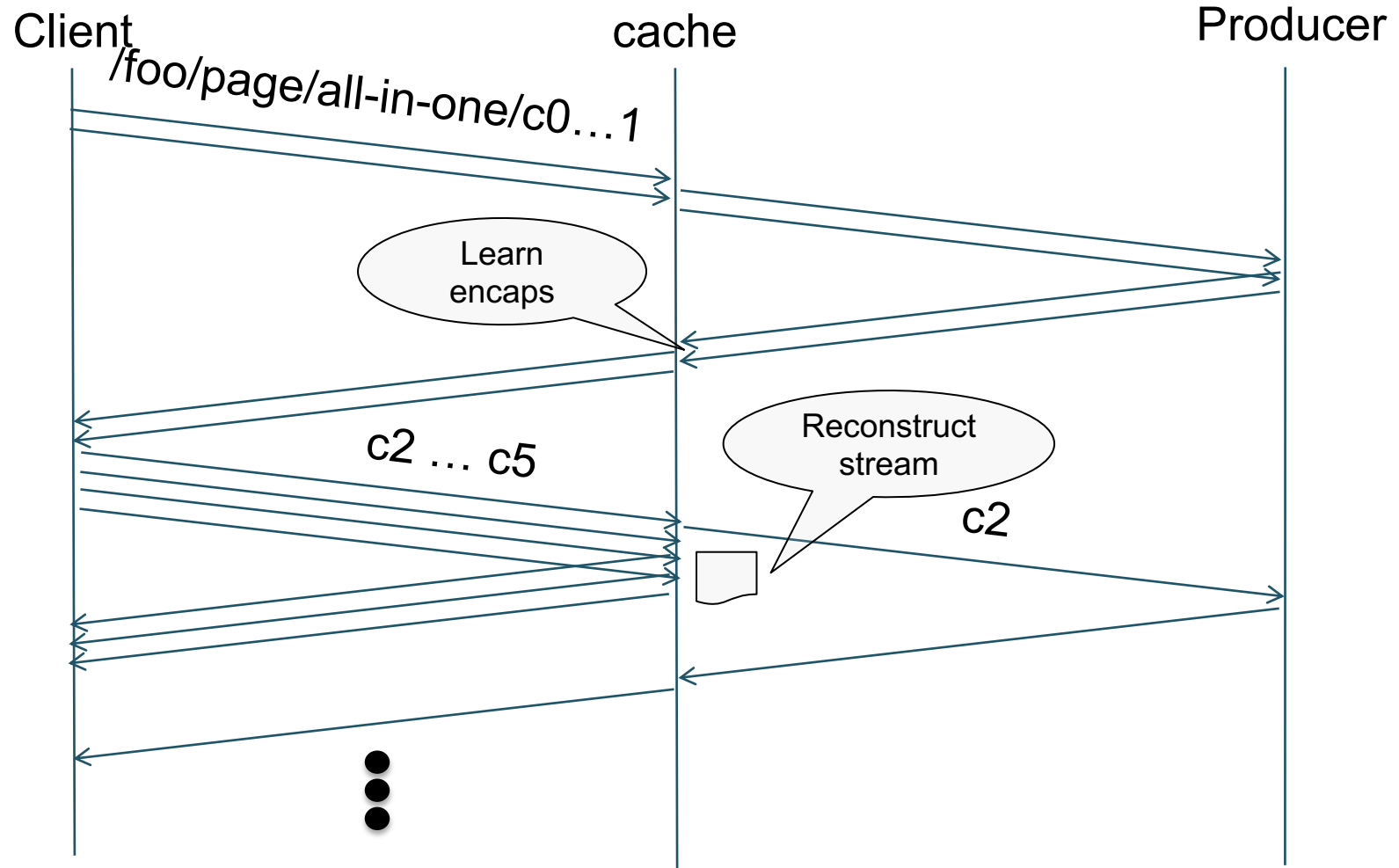
Producer

/foo/page/all-in-one/c0...1

Learn  
encaps



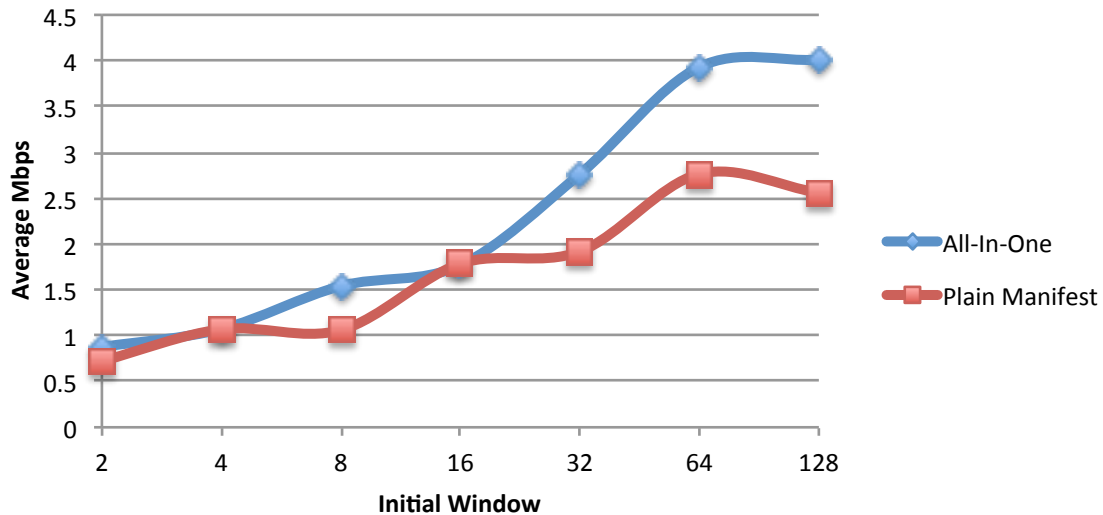
/foo/markup/c0



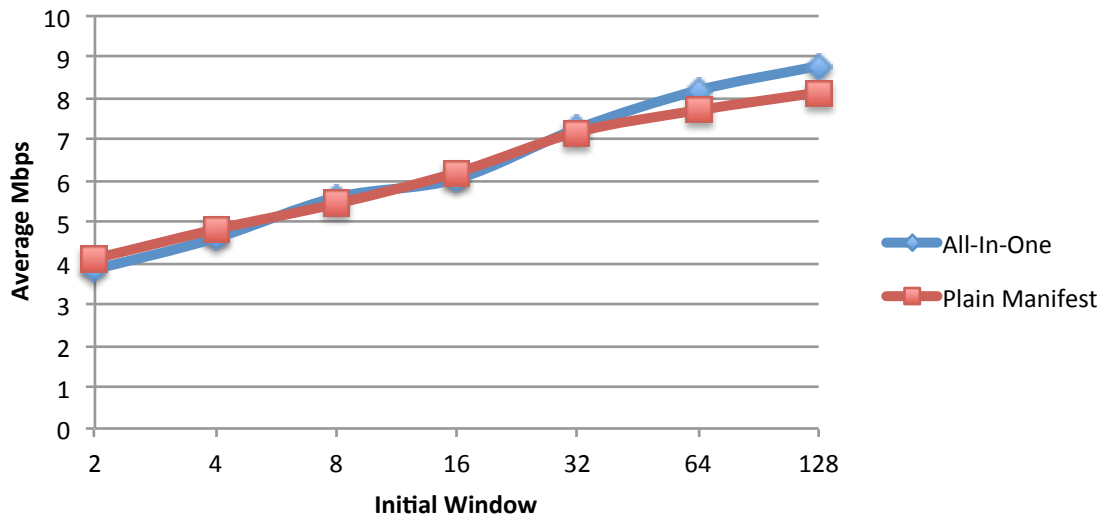
# MODELING PERFORMANCE

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- Compare All-In-One with TCP-like behavior.
- Each stream is 3, 10, or 30 embedded objects.
- Each object is uniformly 1KB – 50KB.
- Content Objects chunked to 1400 bytes (to fit in 1500 byte MTU).
- 10 Mbps bottleneck link.
- Doubling Interest window until bottleneck saturated.



Average 86 KB



Average 905KB



# CONCLUSION

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- All-in-one streams addresses slow start on multiple windows when downloading multiple related objects.
- Uses hash chains from manifests, so only manifest objects need to be signed.
- Including metadata in manifest allows intermediate caches to reconstruct stream contents from cached copies of embedded objects.
- As expected, performance benefit seen primarily for smaller streams (under 1 MB) when using larger initial window.

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**THANK YOU.**