Colorado State University

MANAGING SCIENTIFIC DATA WITH NDN

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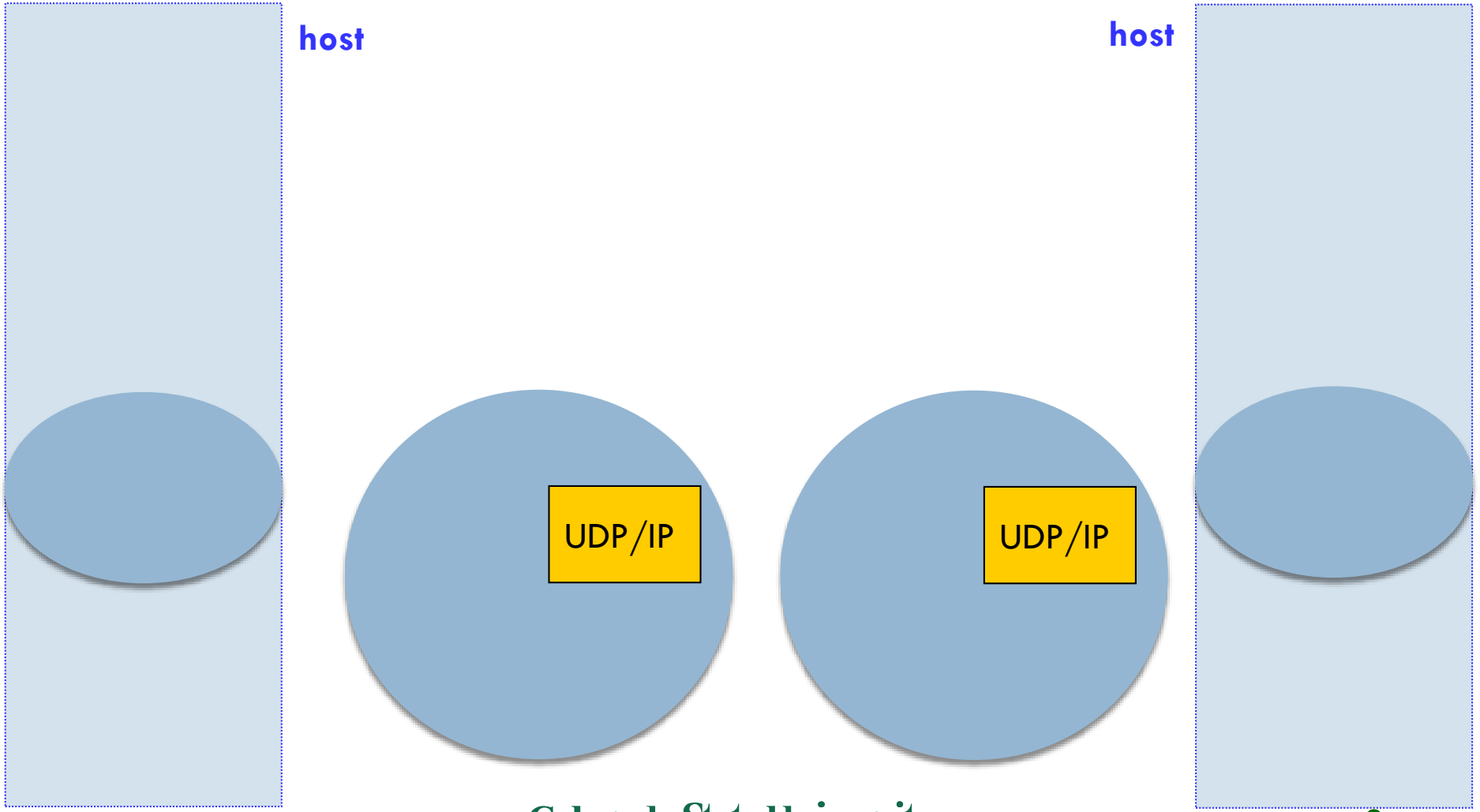
Introduction

- Scientific data is often very large and complex
  - Climate - CMIP5: 3.5 PB, CMIP6: 350PB-3EB
  - Physics - Atlas: 4 PB/Year
  - Astronomy, bioinformatics, others…
- Science infrastructure
  - Cutting edge hardware but often incompatible domain software (ESGF, xrootd, etc.)
  - Complexity, replication, redundancy

Our Project

- Build and deploy software to evaluate NDN in scientific applications over a dedicated hardware infrastructure
- Evaluate NDN in the context of:
  - Application services: publishing, discovery, retrieval, access control, load balancing, failover, caching, etc.
  - Network integration (OSCARS, SDN, etc.)
- Metrics
  - Performance, reduced complexity, ease of deployment, interoperability, reuse, efficiency, routing, security/trust, etc.

NDN Layer Structure



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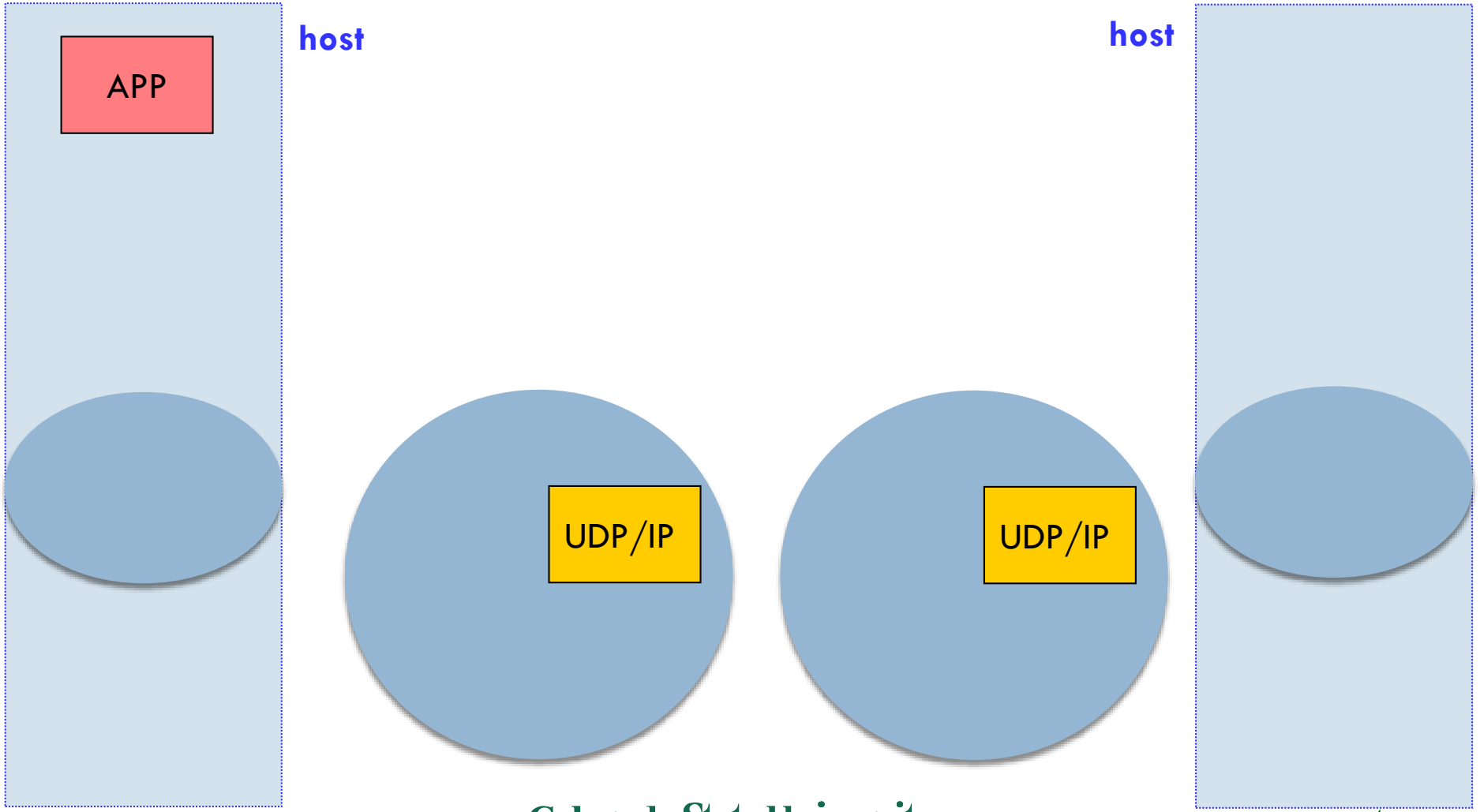

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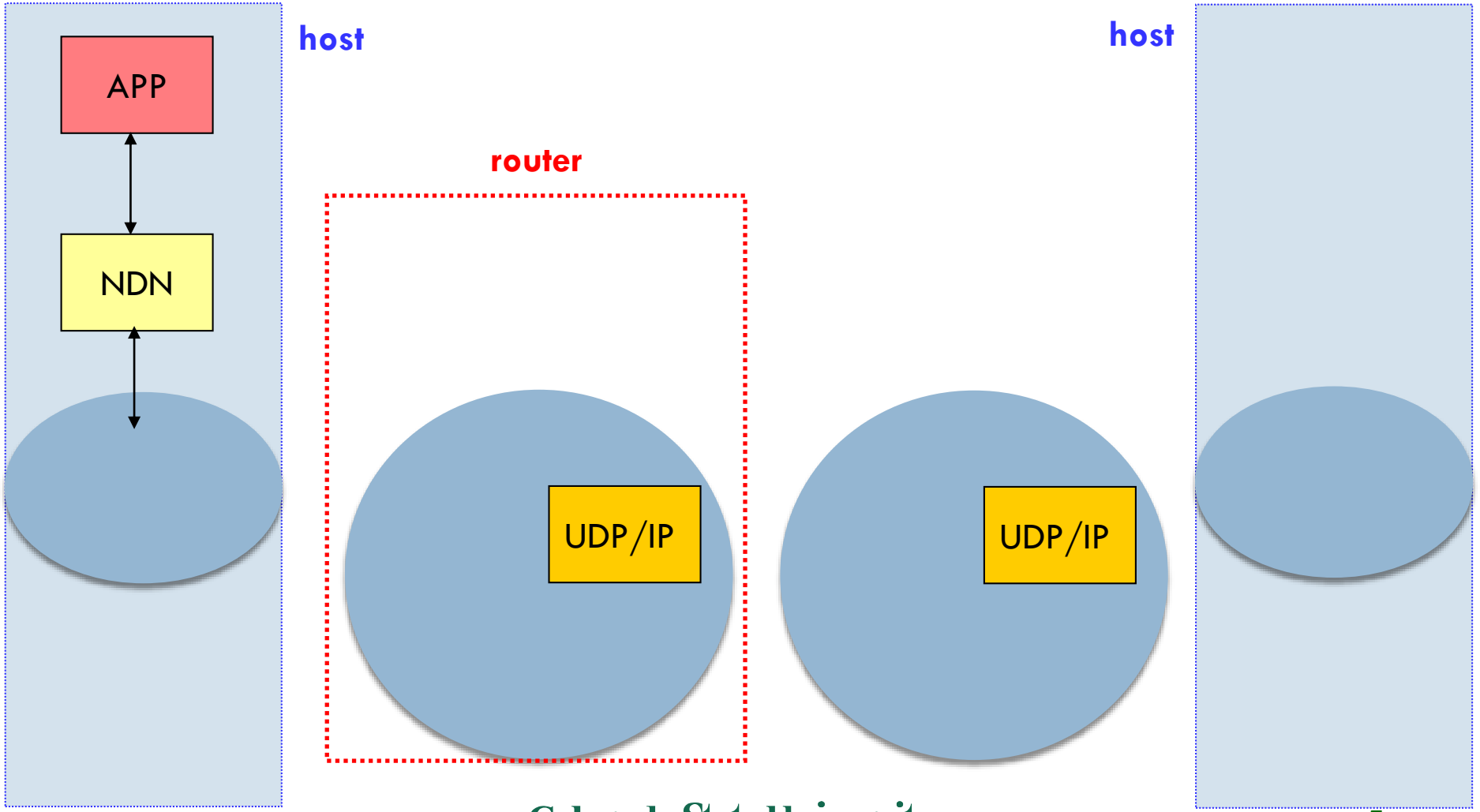

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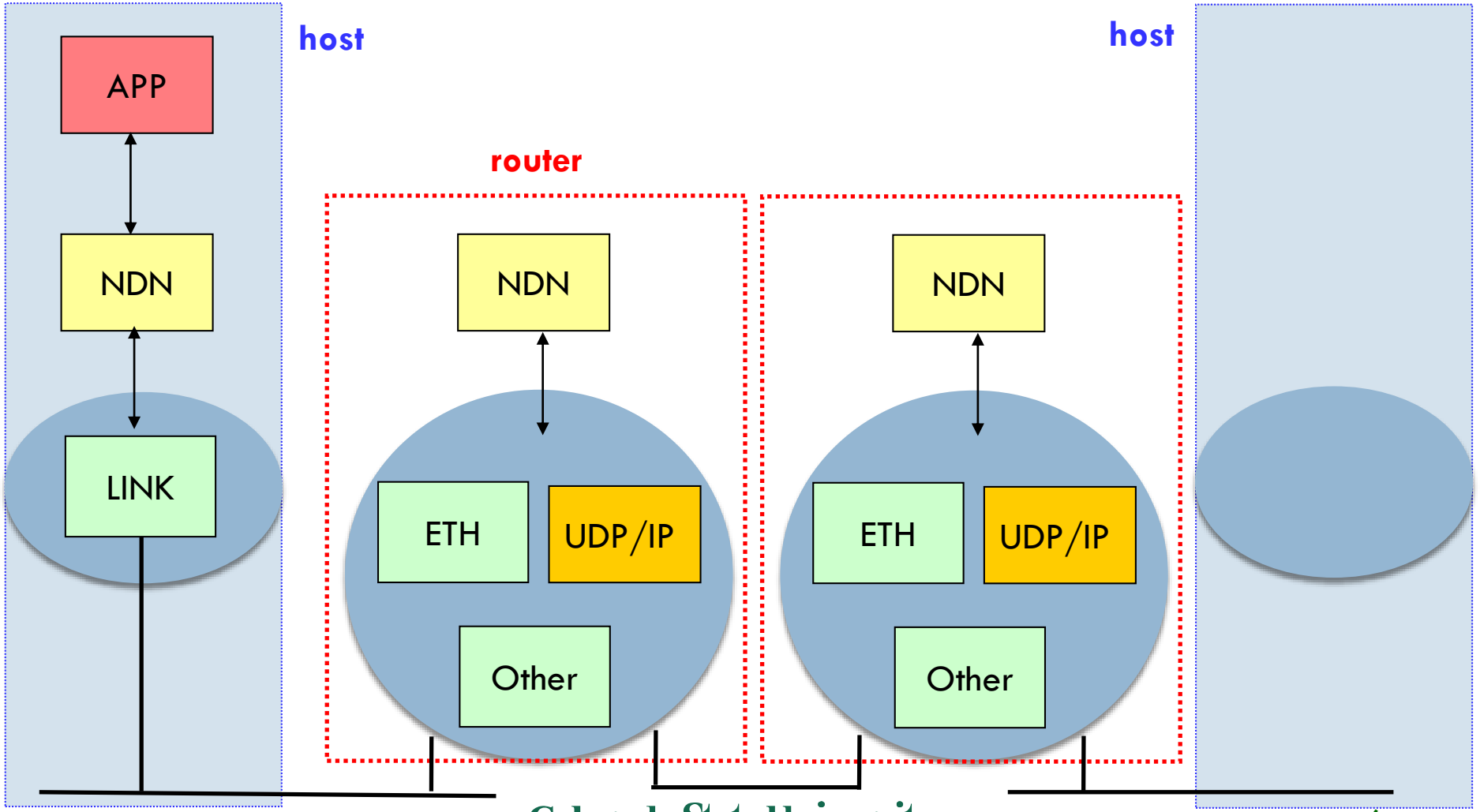

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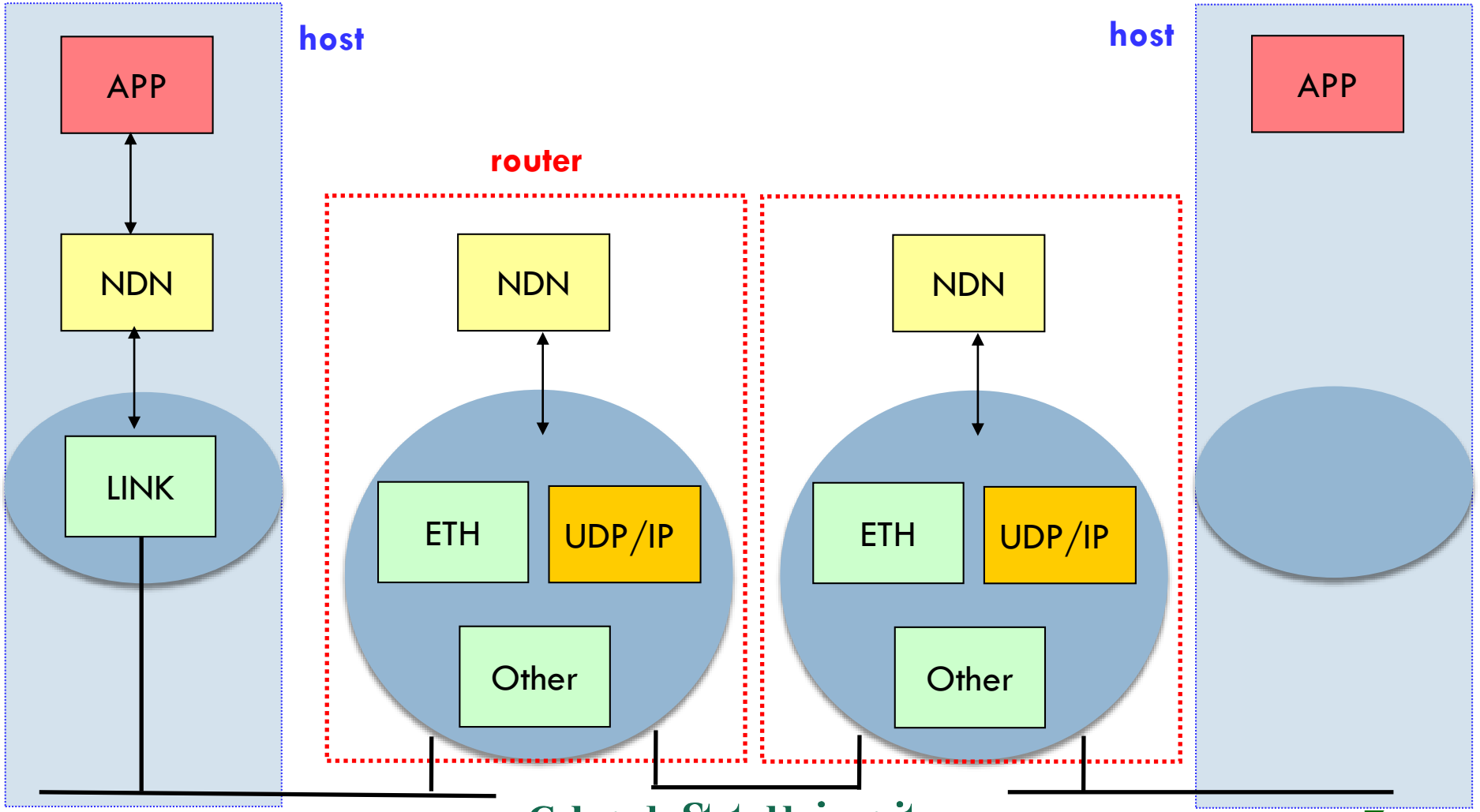

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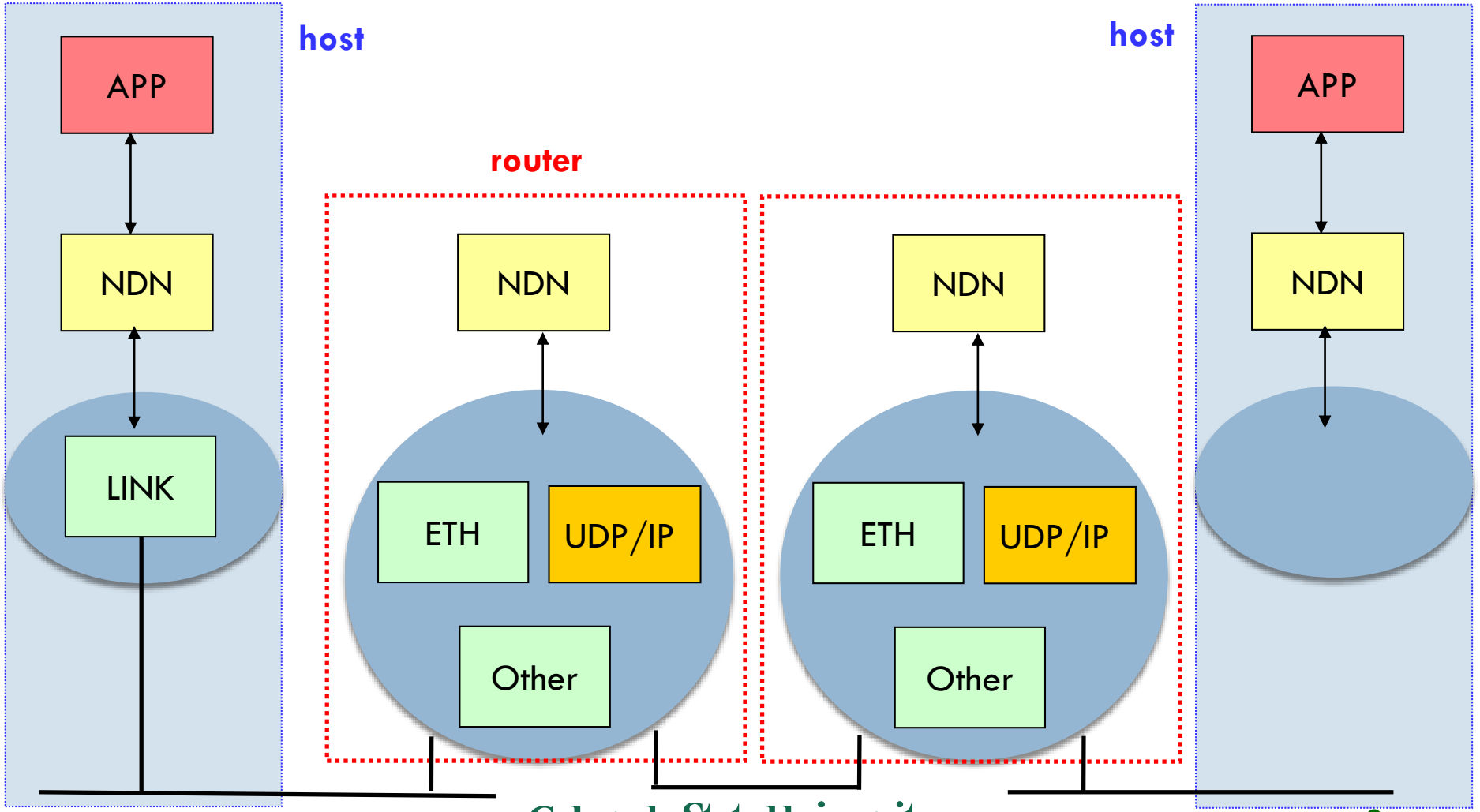

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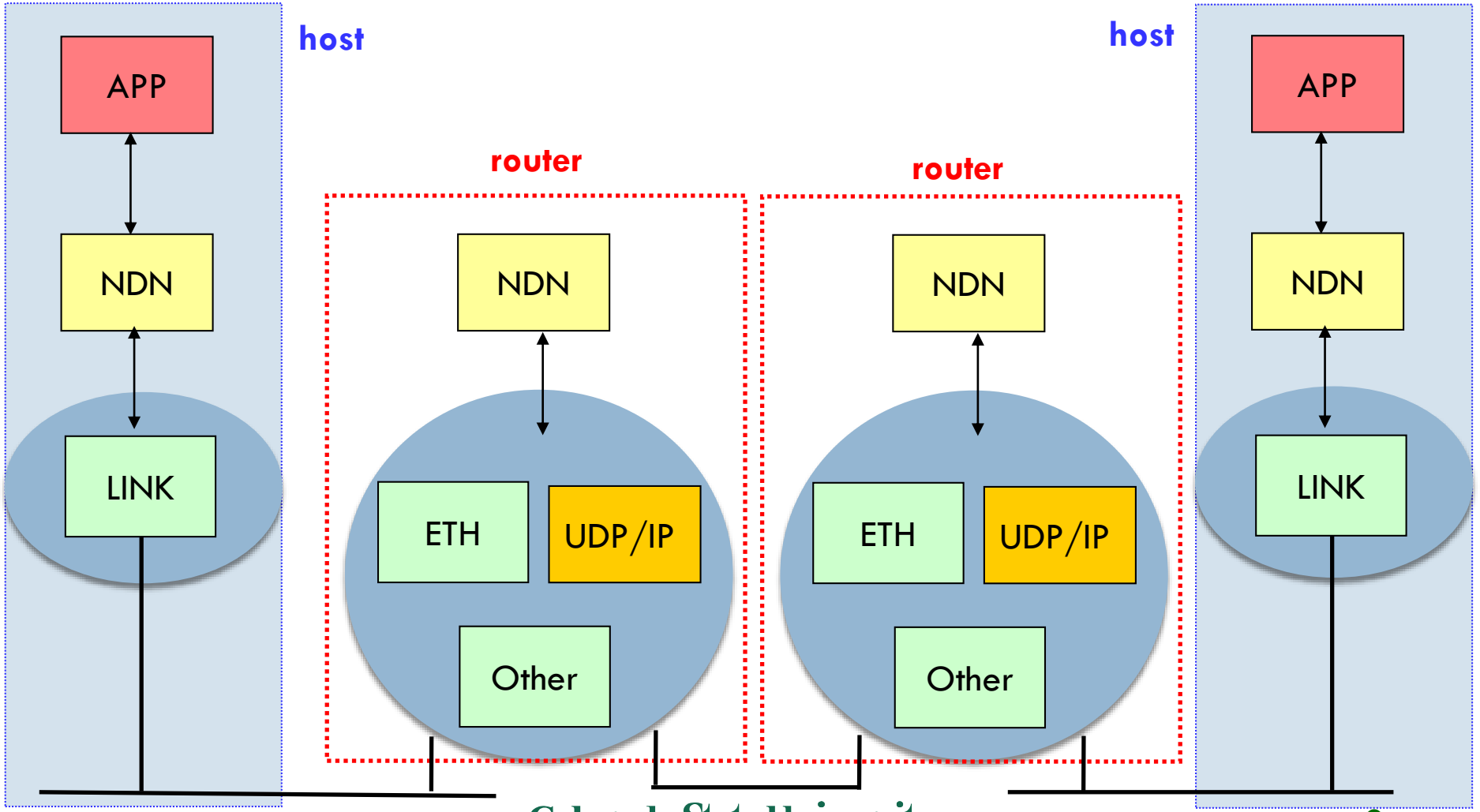


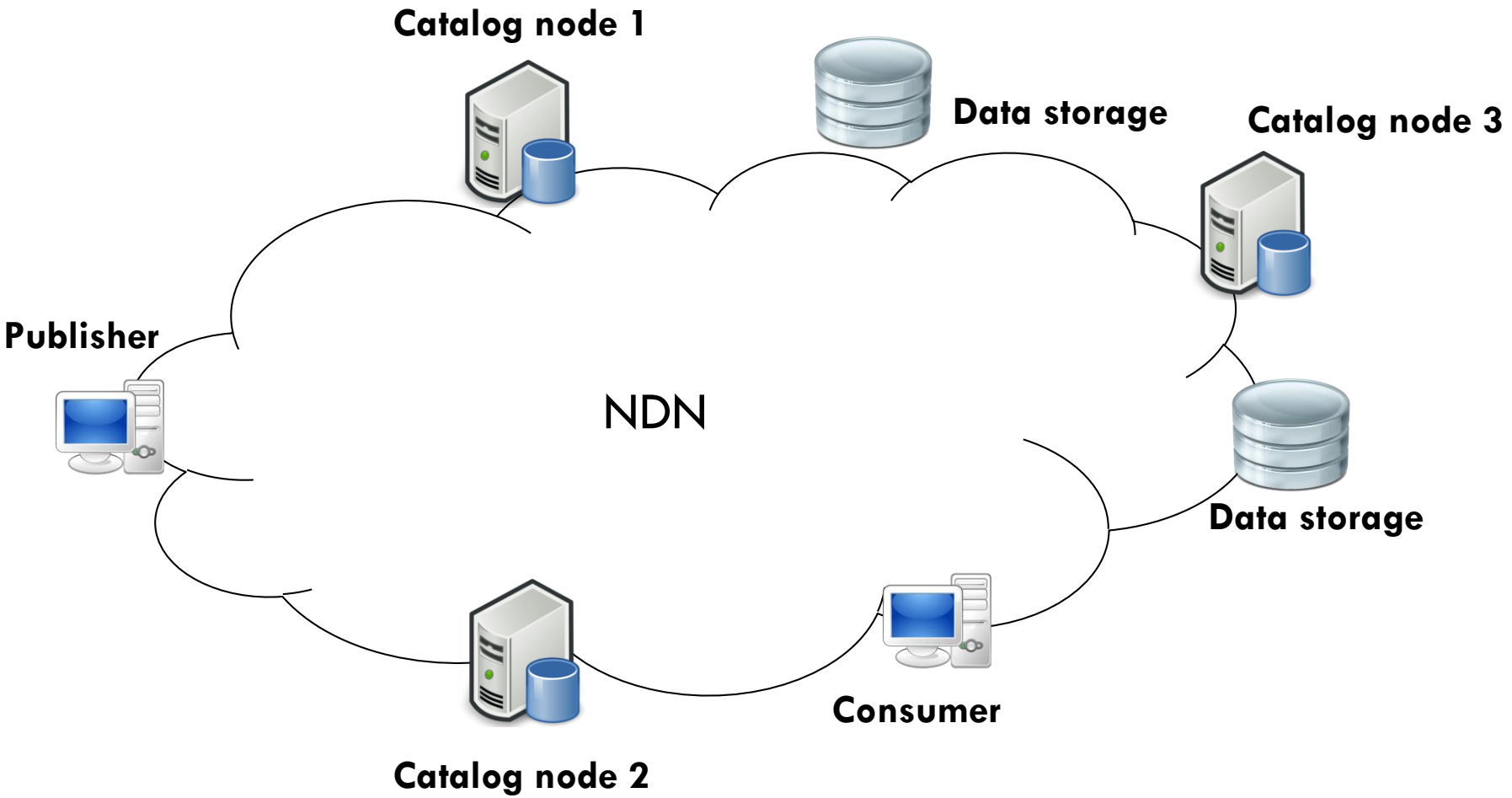
Methodology

- Investigate the use of NDN as a common platform for scientific data applications by:
  - Understanding data management challenges of various scientific domains
  - Developing and evaluating prototype applications that leverage NDN's features
  - Use prototypes to further drive NDN research

First Step – Build a Catalog

- Create a **shared resource** – a distributed, synchronized catalog of names over NDN
  - Provide common operations such as publishing, discovery, access control
  - Catalog only deals with name management, not dataset retrieval
  - Platform for further research and experimentation
- Research questions:
  - Namespace construction, distributed publishing, key management, UI design, failover, etc.
  - Functional services such as subsetting
  - Mapping of name-based routing to tunneling services (VPN, OSCARS, MPLS)

Overview of Catalog Workflow



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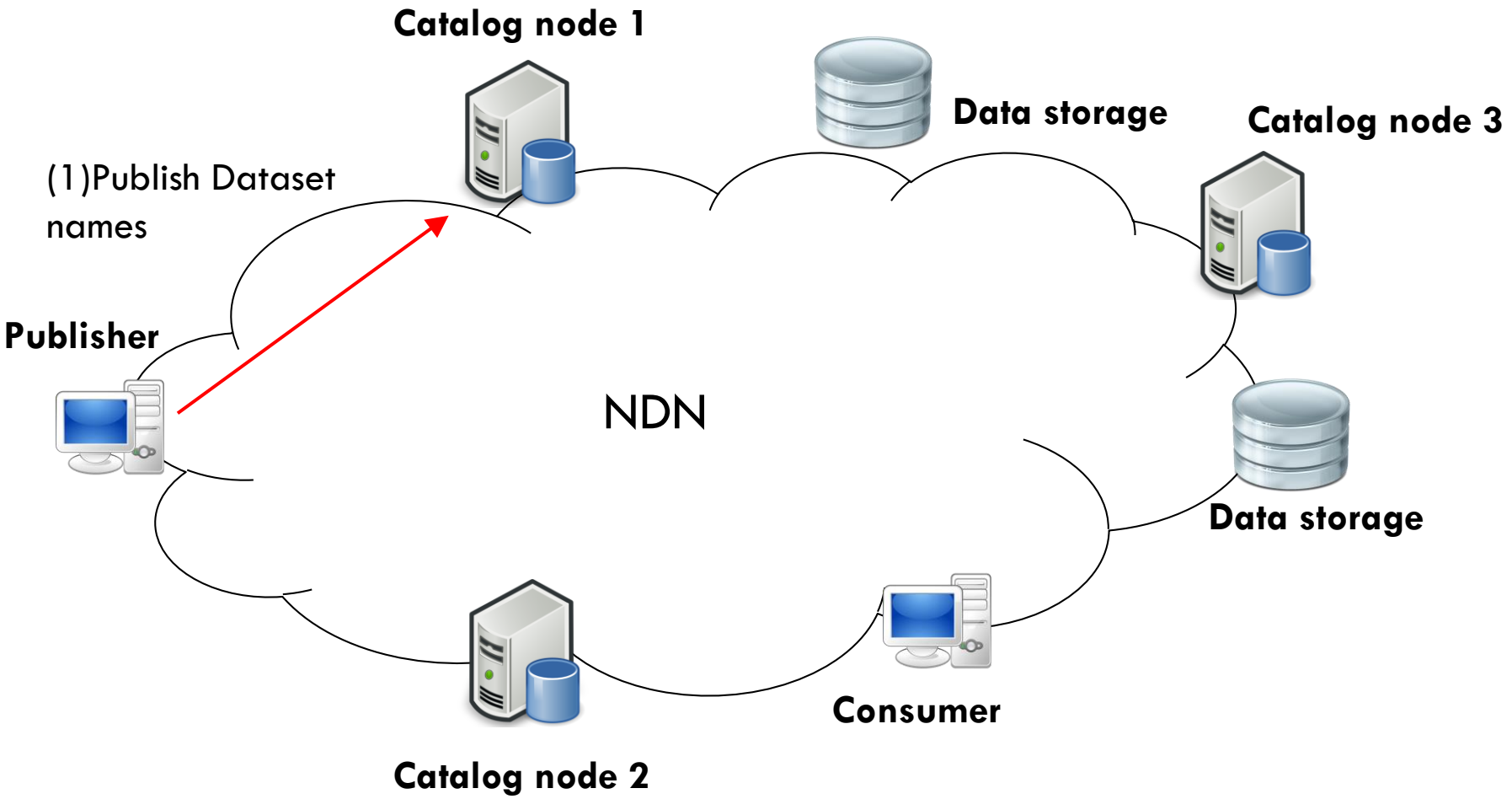

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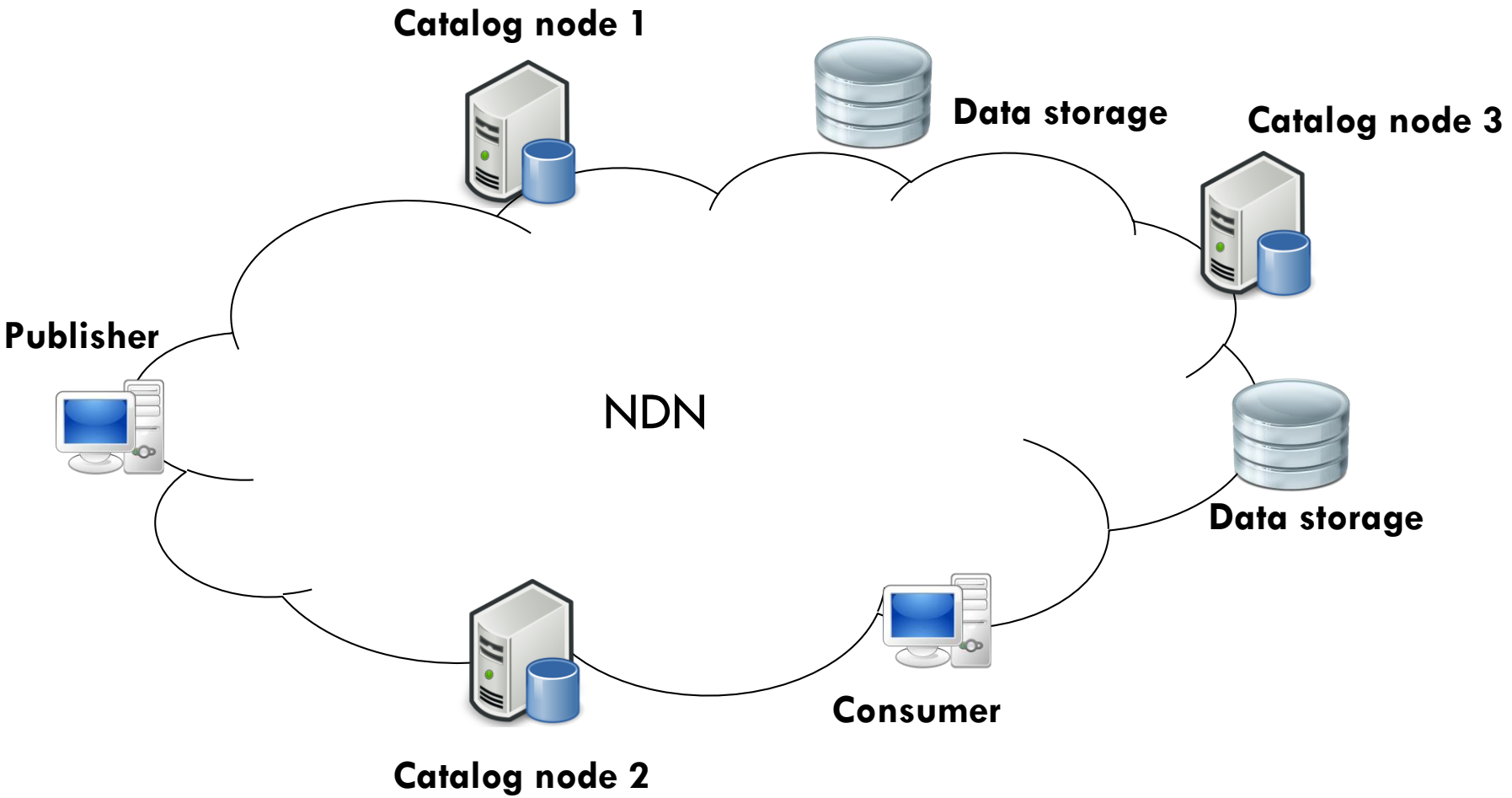

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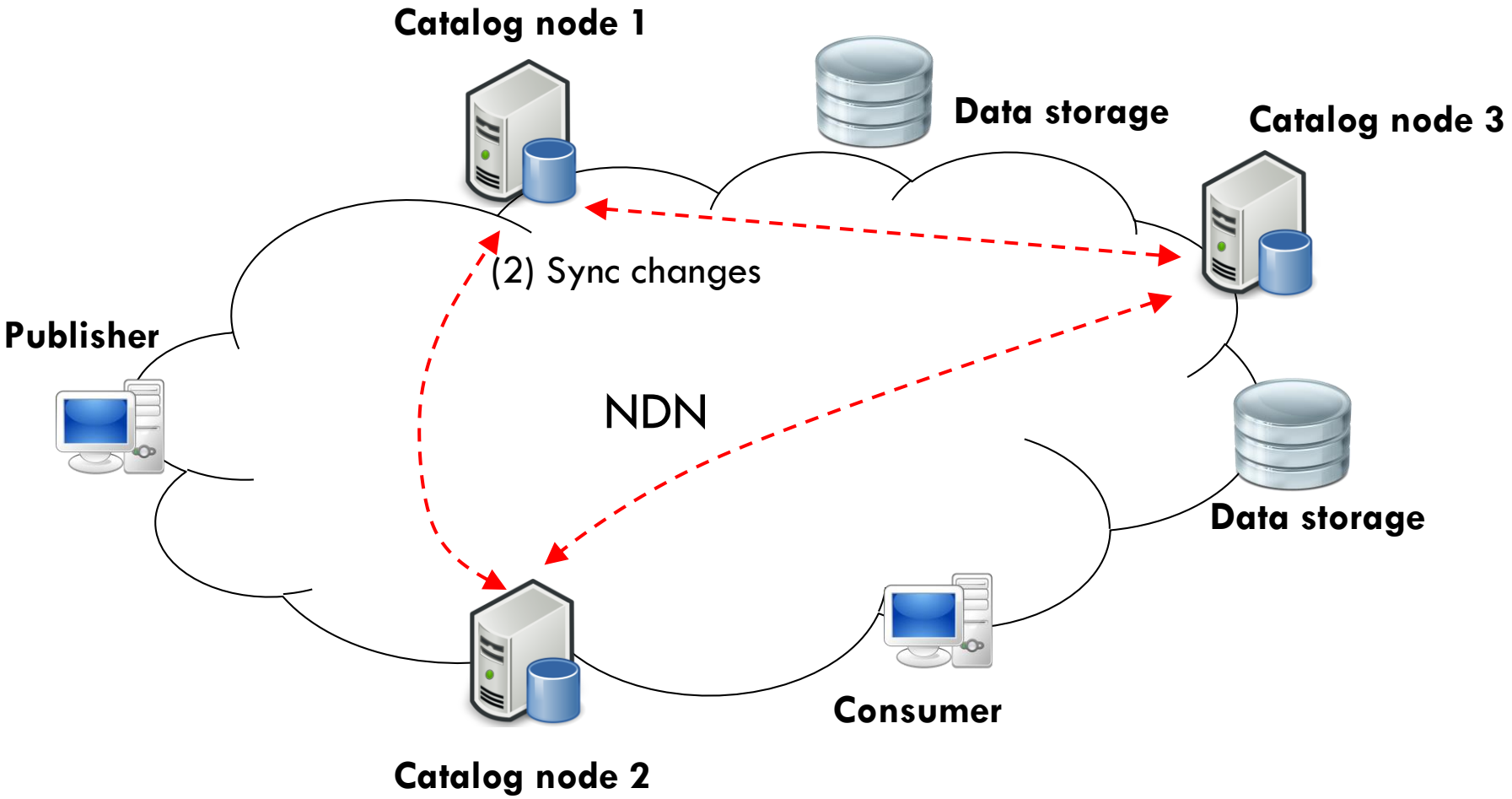

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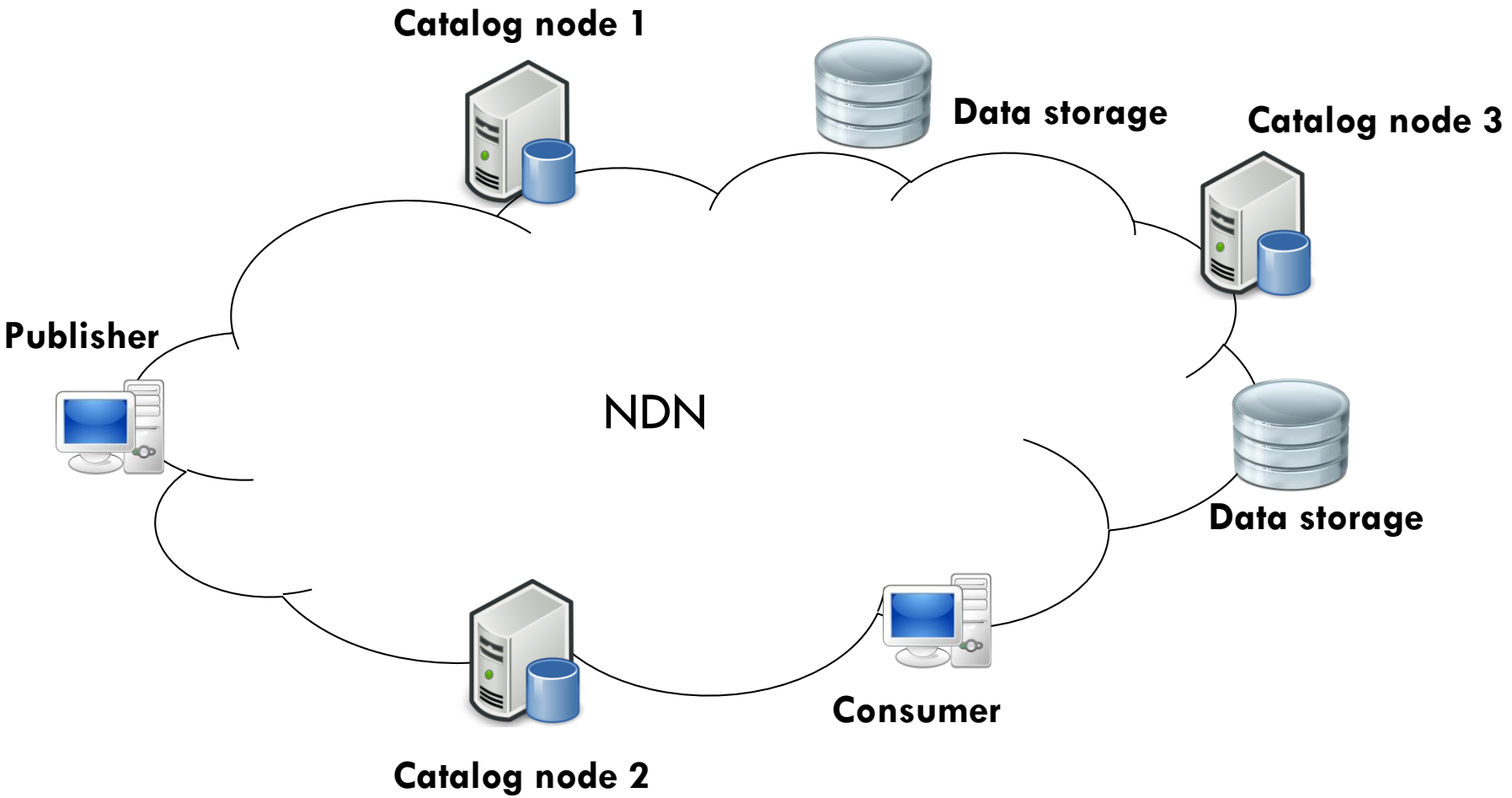

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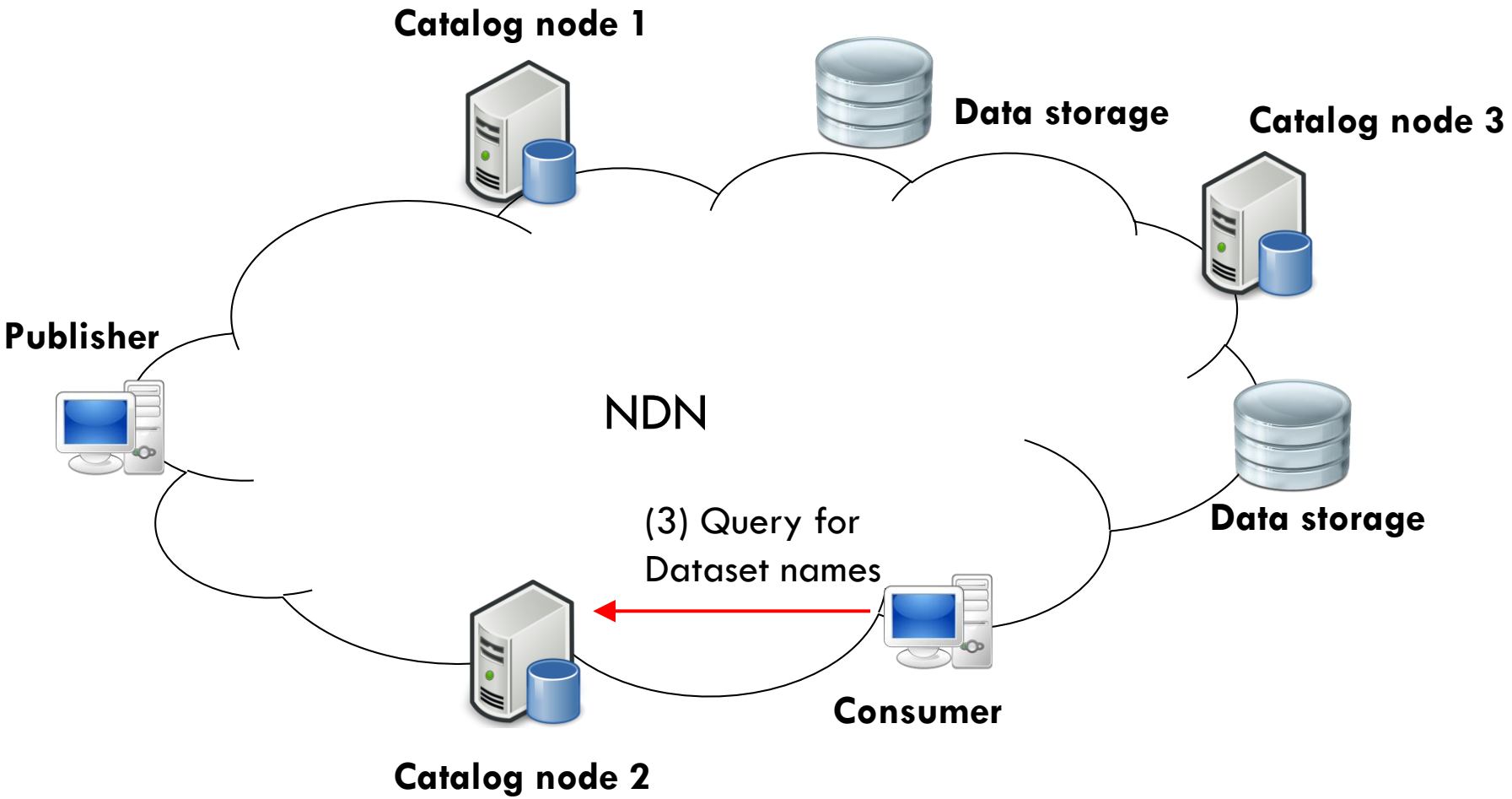

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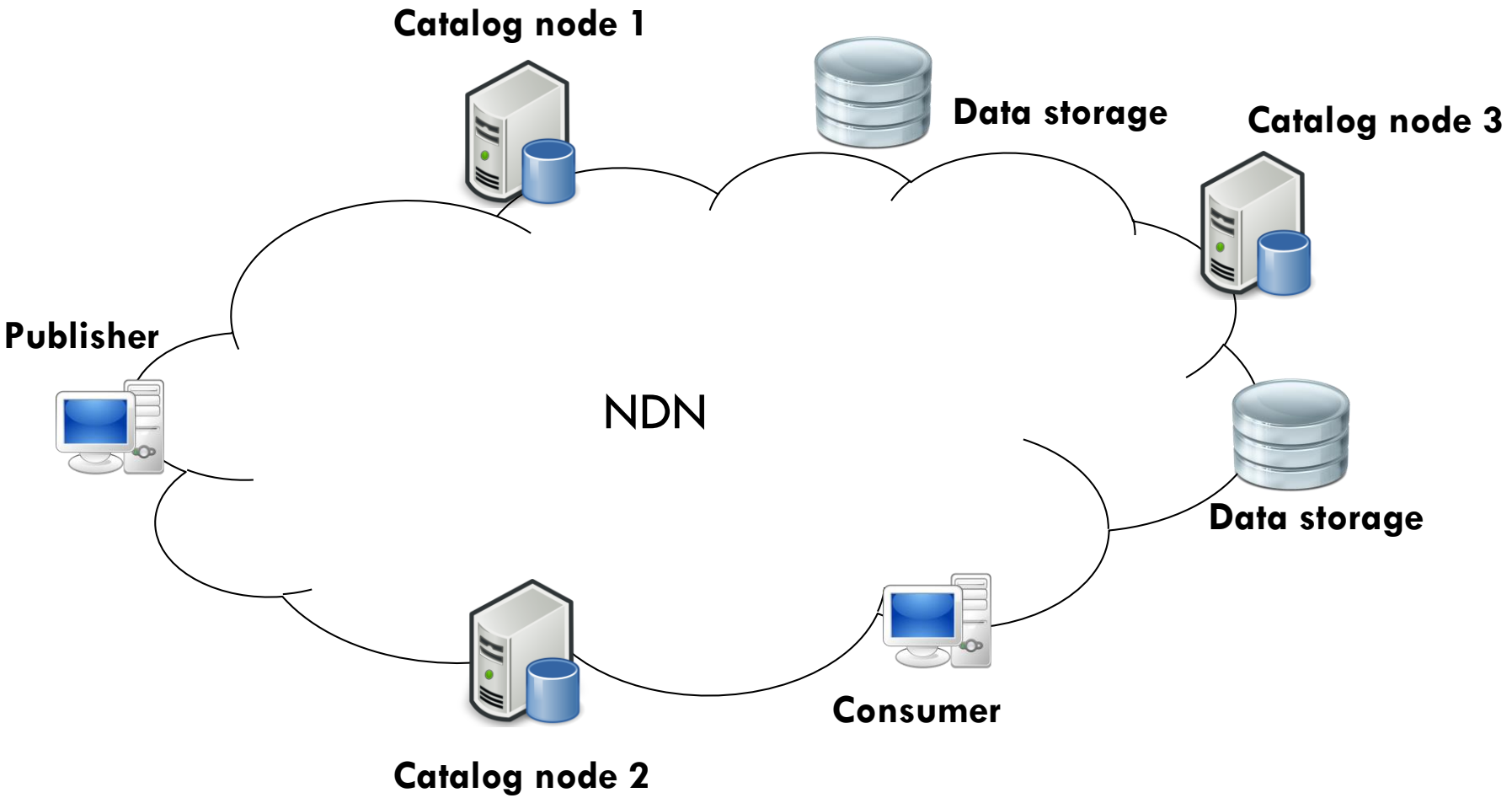

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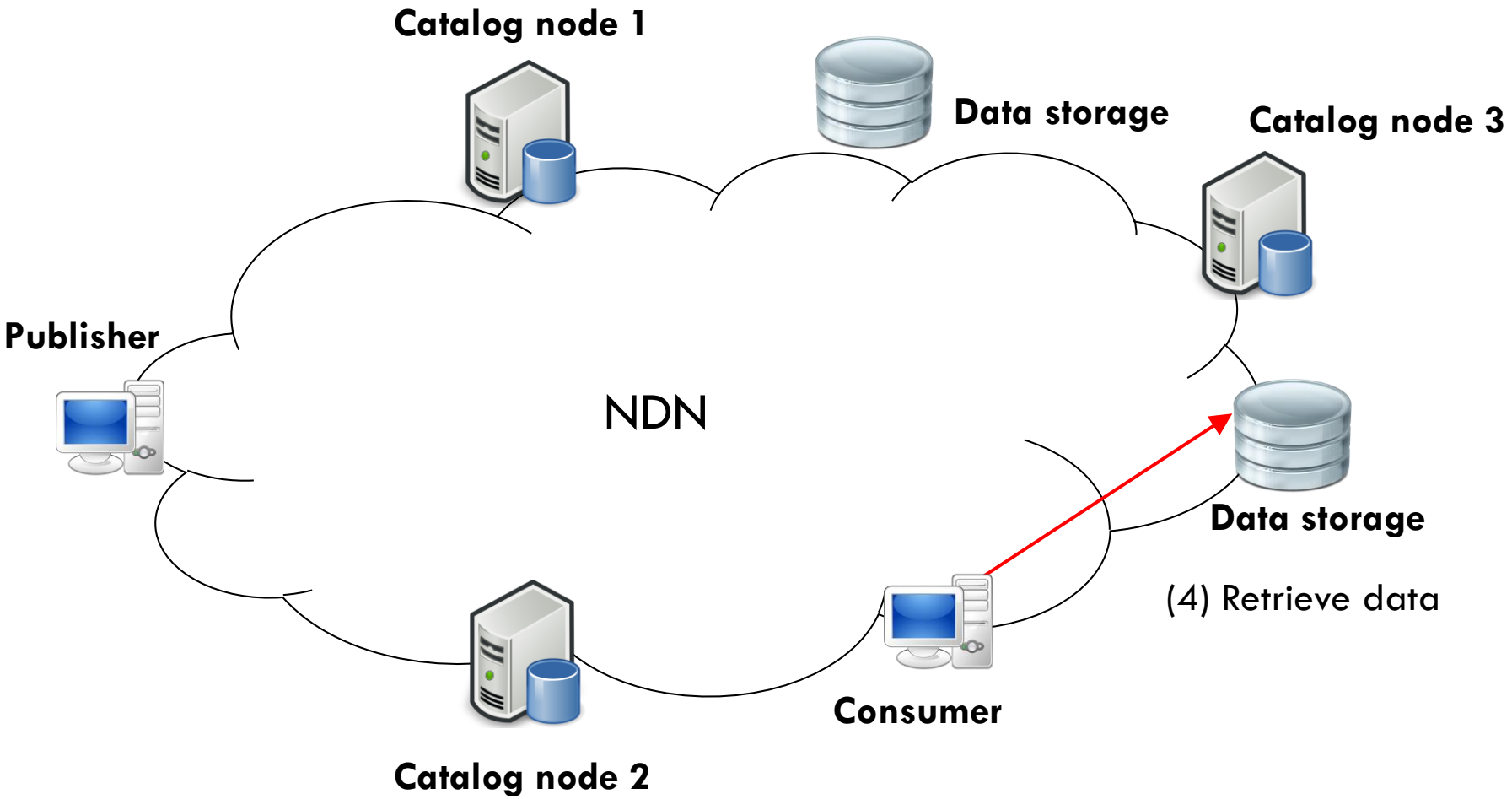

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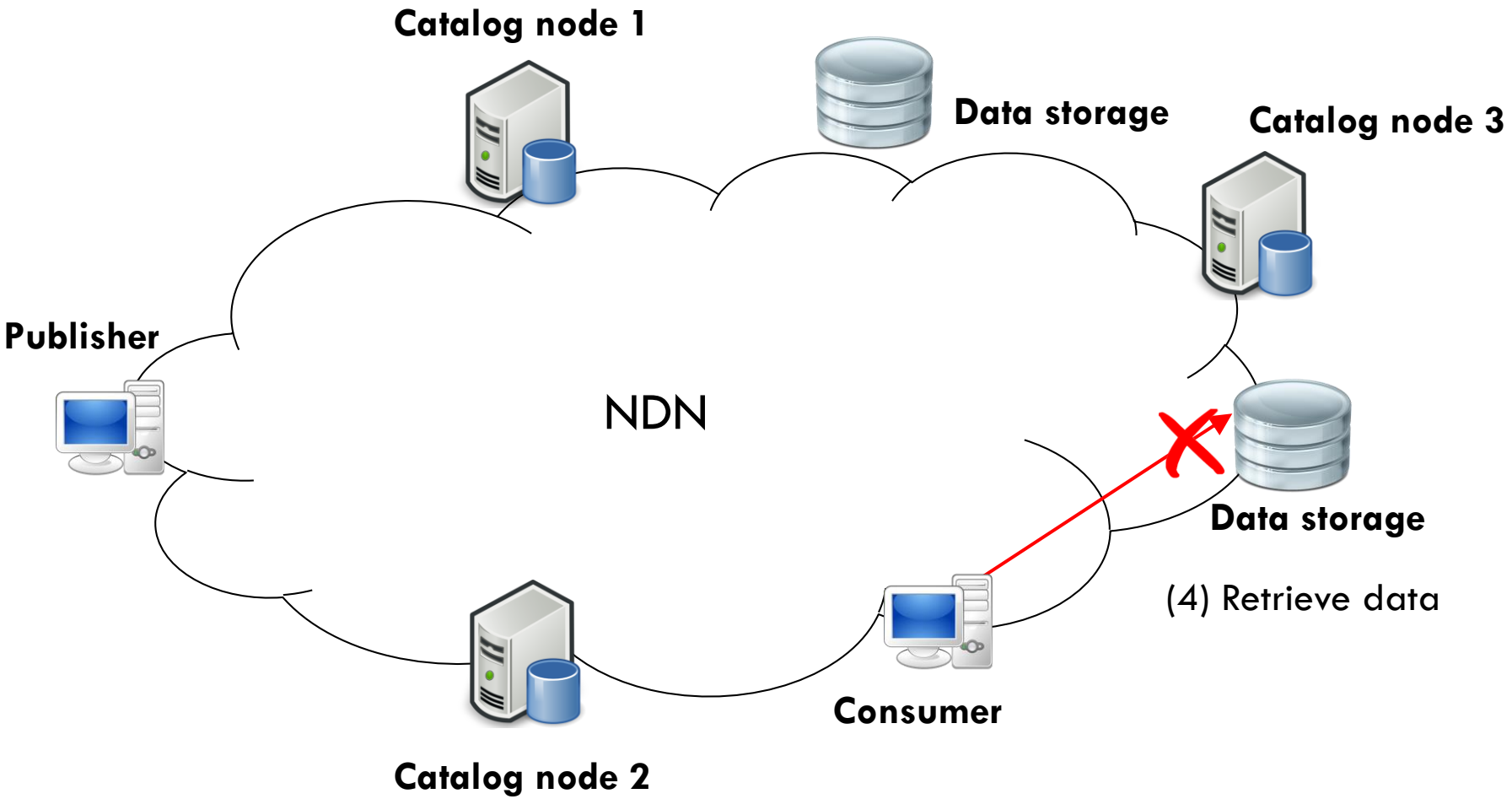

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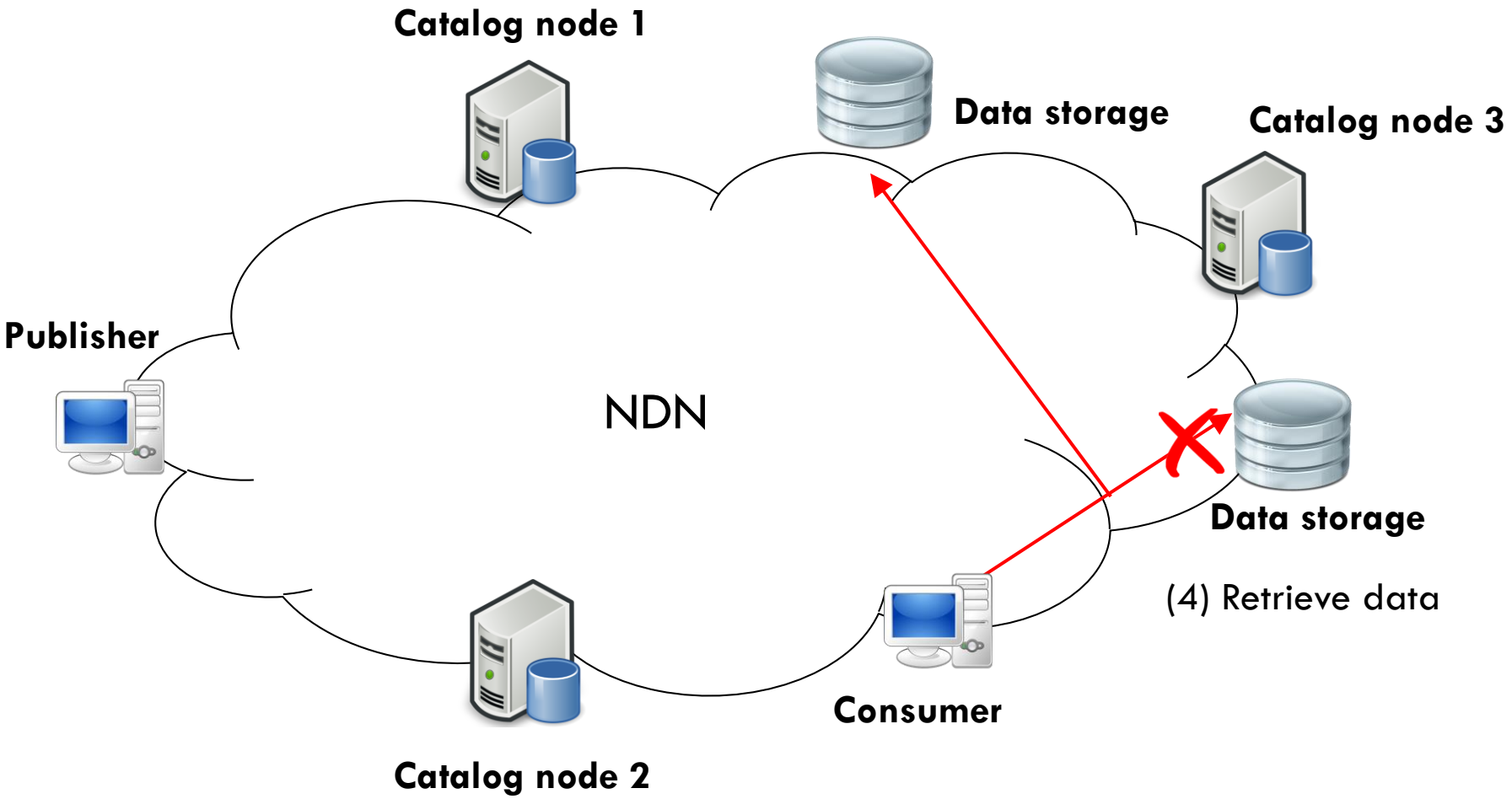
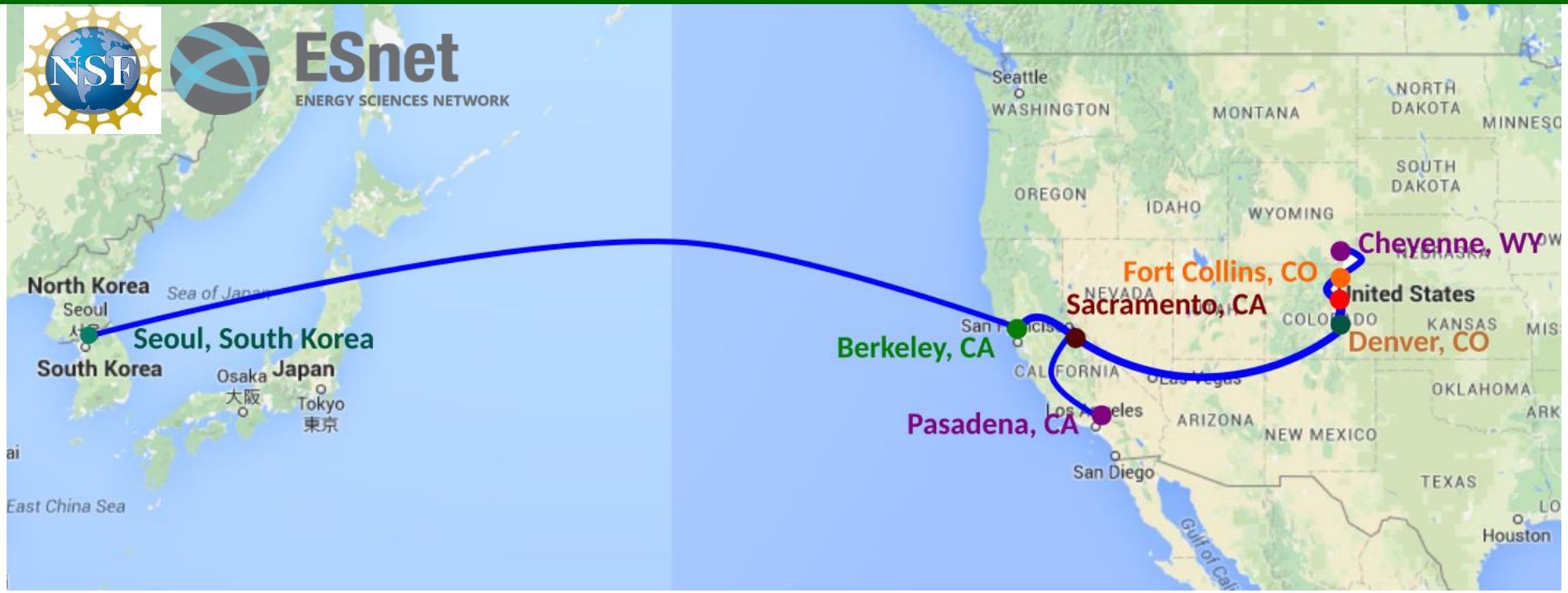


NDN-Science Testbed



- NSF CC-NIE campus infrastructure award
  - 10G testbed (courtesy of ESnet, UCAR, and CSU Research LAN)
- Currently ~50TB of CMIP5, ~70TB of HEP data

Demos

- Search
- Publication and Sync
- Access control
- Retrieval and failover

Conclusions

- IP encourages common **host** access, not common **data** access methods
  - Does not encourage interoperability at the application level
- NDN has the potential to unify the service interface required by scientific applications
  - Science testbed and prototypes to test hypothesis and drive research and experimentation
- Ready-to-try catalog, we invite you to try it with your data
  - Catalog is general, supports a variety of applications
  - Currently CMIP5 and HEP applications
  - UI for data search and retrieval.

Thanks

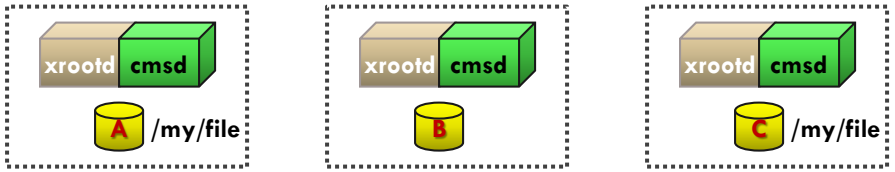
Our sponsors: NSF and ESnet

Join us @

http://www.netsec.colostate.edu/mailman/listinfo/ndn-sci

Backup Slides

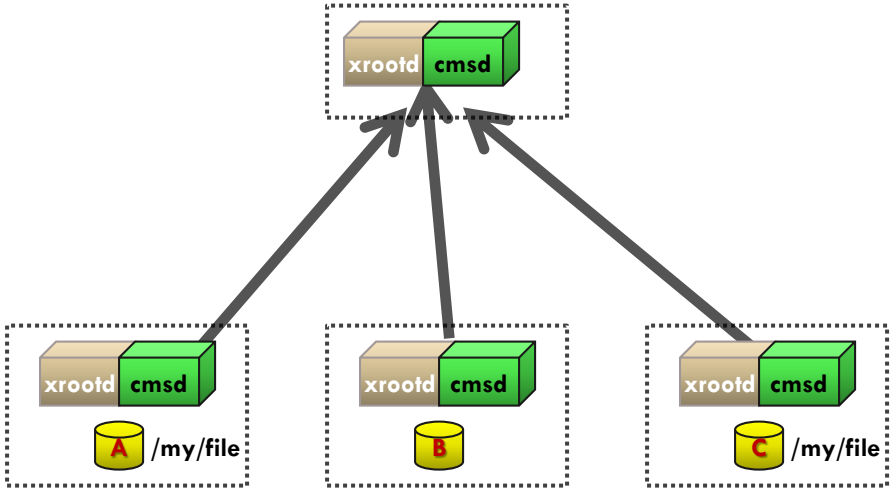
Current Example: xrootd



Data Servers

- Fragile, fairly complex middleware

Current Example: xrootd



Manager
(a.k.a. Redirector)

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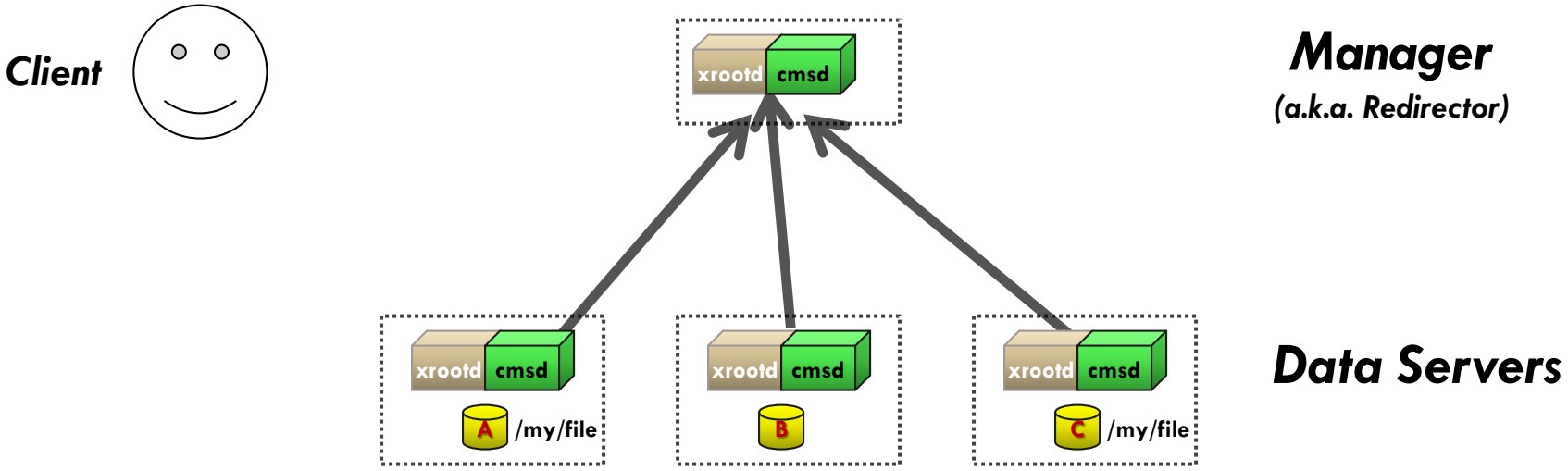

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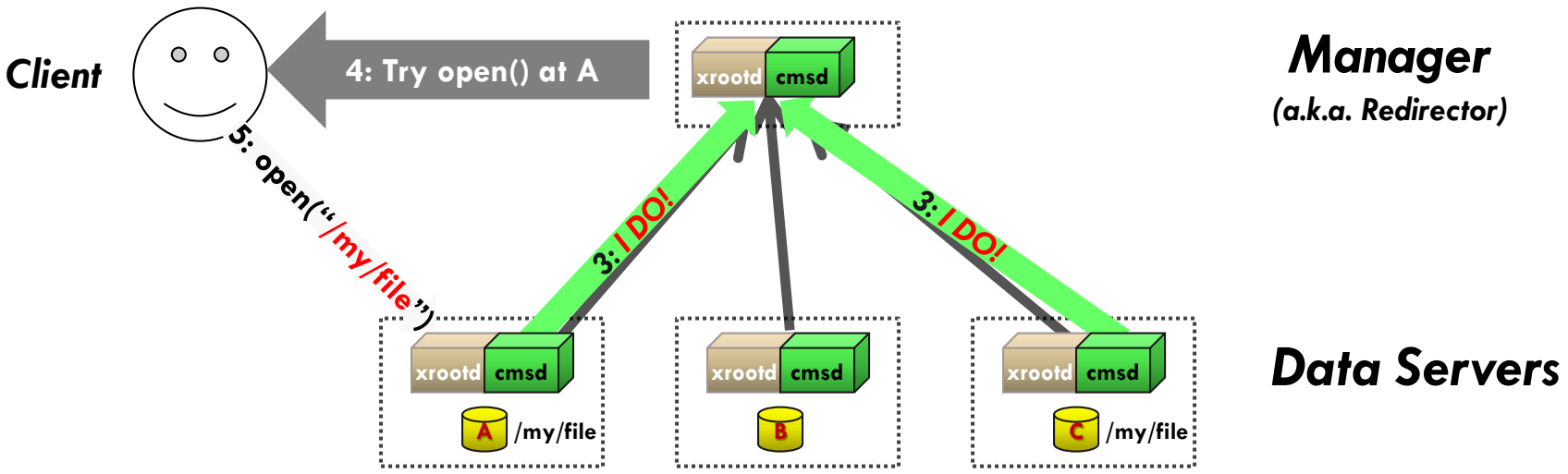

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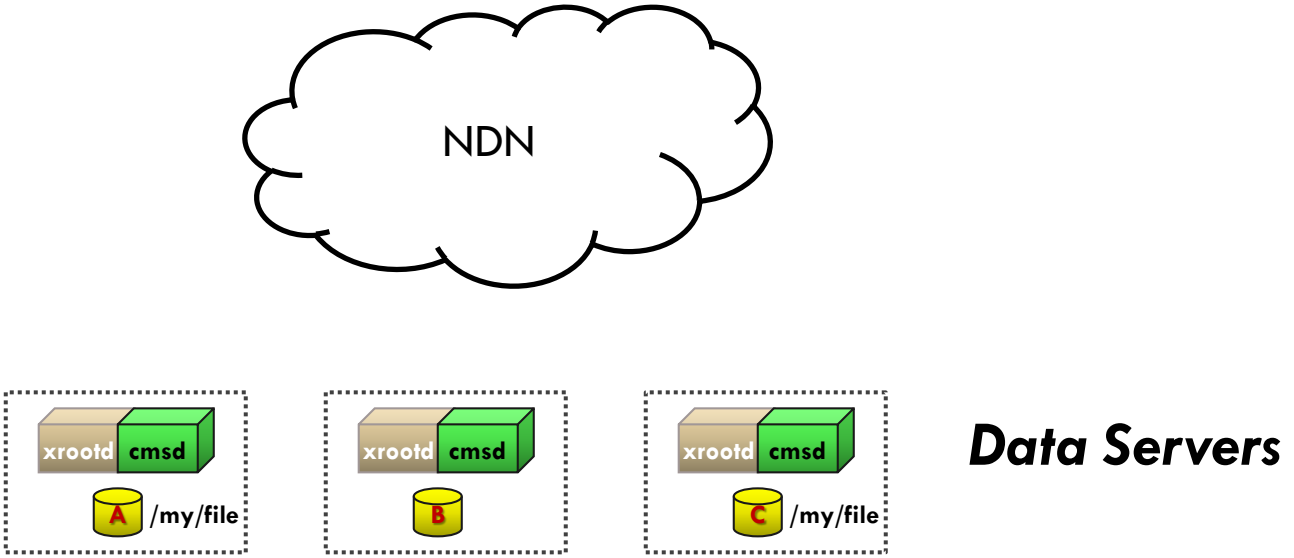
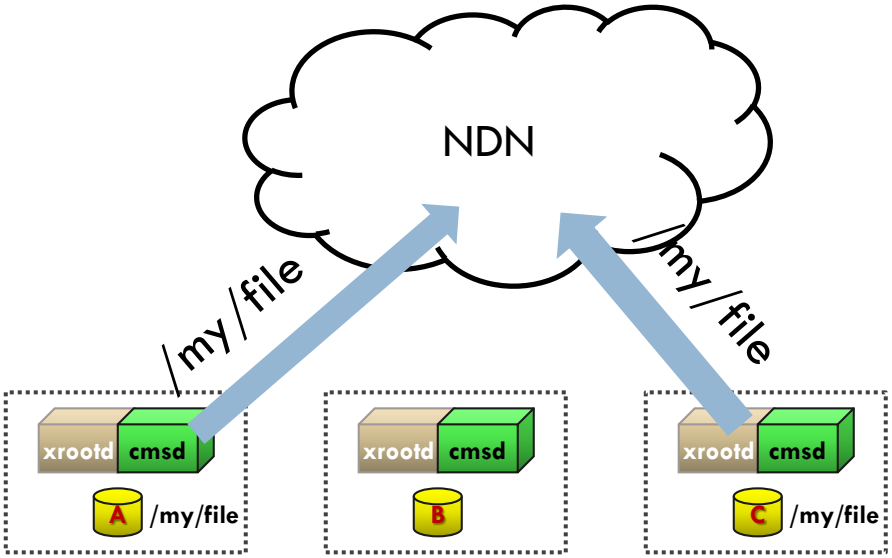
xrootd under NDN



- Significantly reduced system complexity
- Better service abstraction

xrootd under NDN



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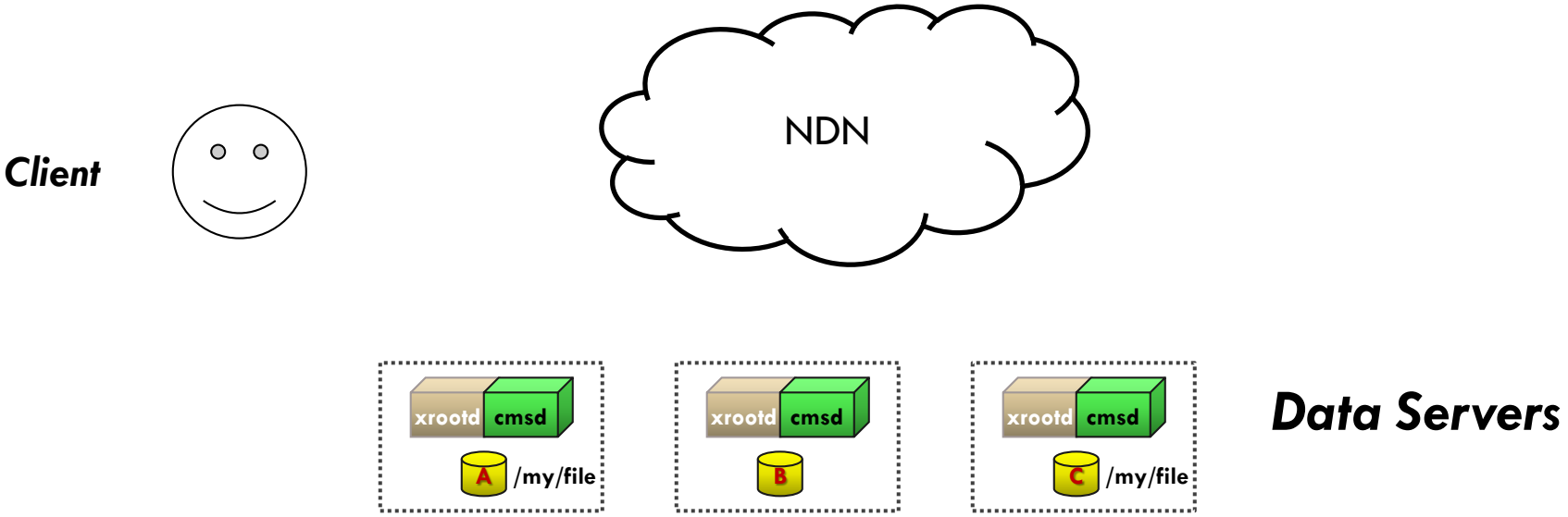

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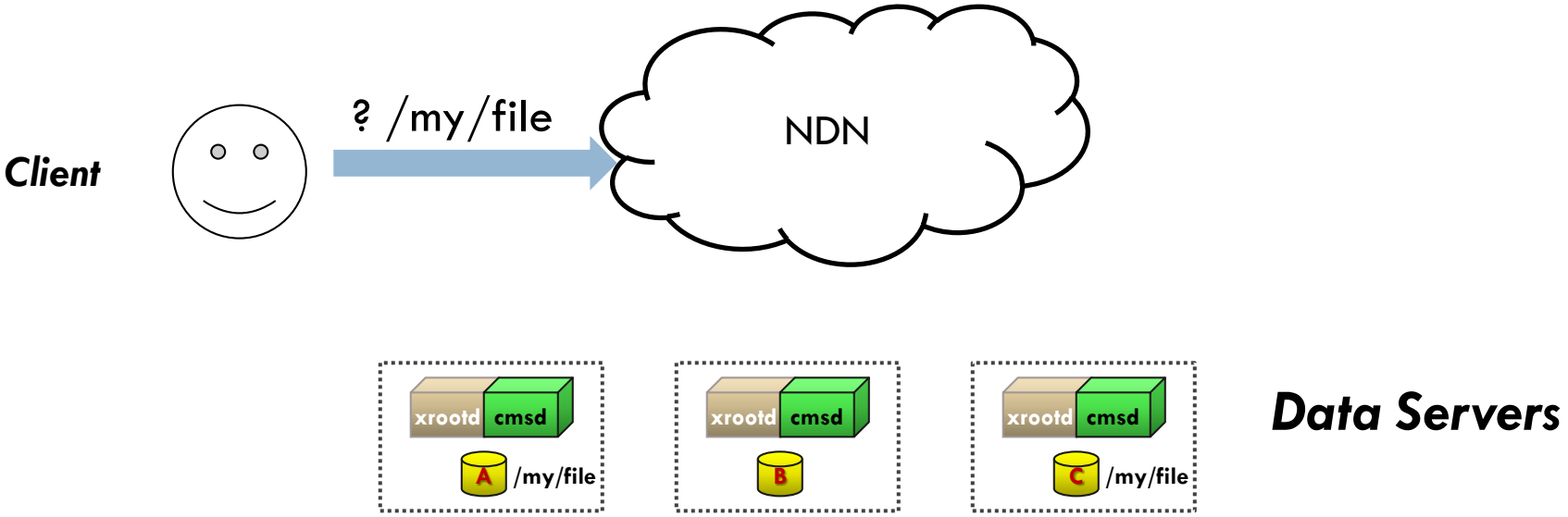

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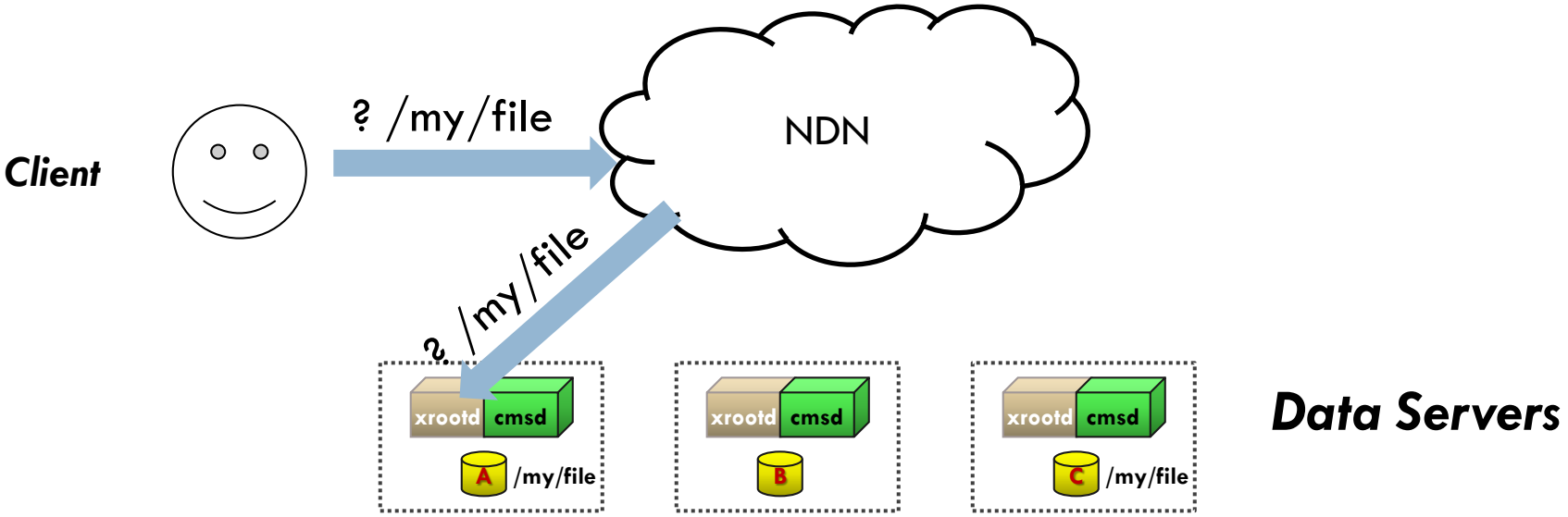

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Data Publication

Catalog

Publisher

1) Listening on /<catalog-prefix>/publish

Data Publication

Catalog

1) Listening on /<catalog-prefix>/publish

Publisher

2) Generate NDN names for datasets/services

Data Publication

Catalog

Publisher

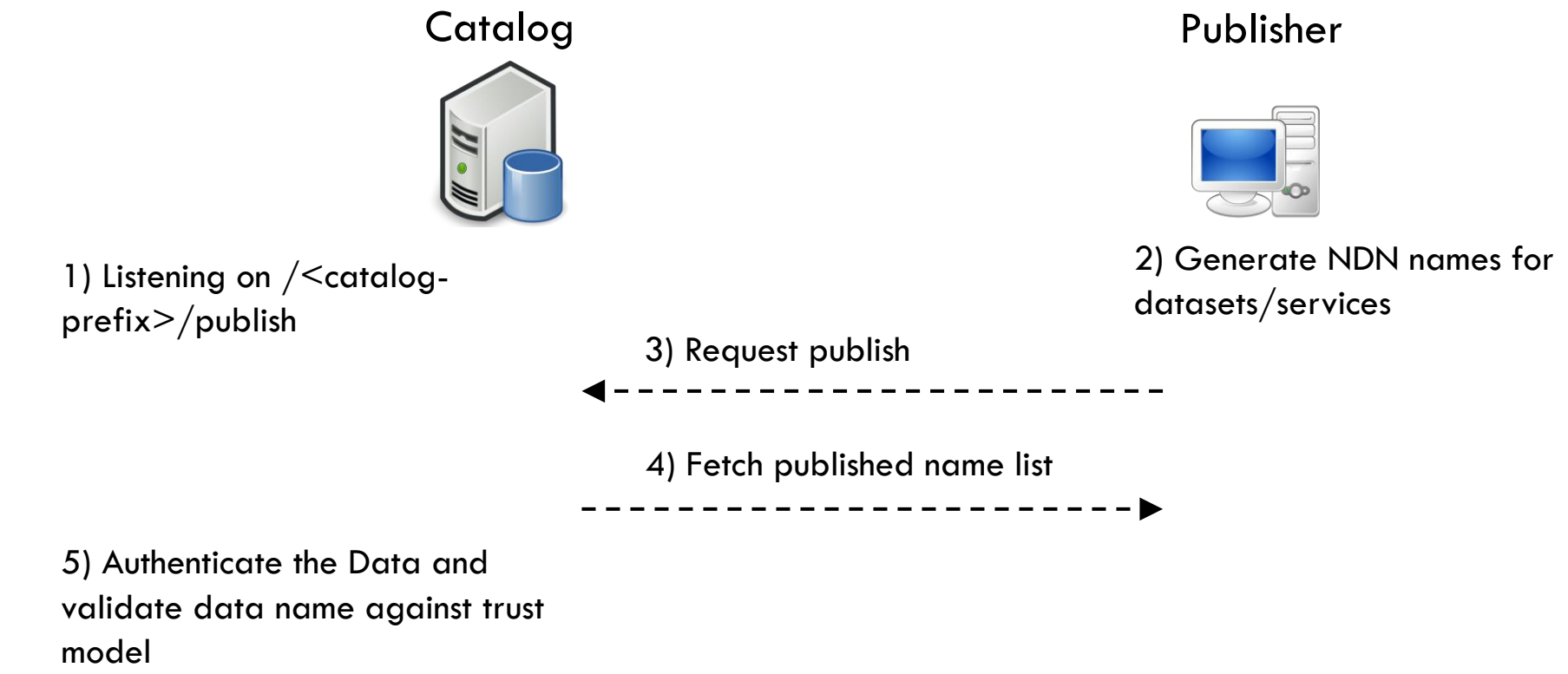
1) Listening on /<catalog-prefix>/publish

2) Generate NDN names for datasets/services

3) Request publish

Data Publication

Data Publication



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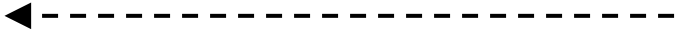
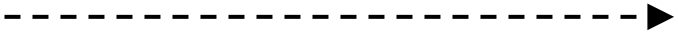


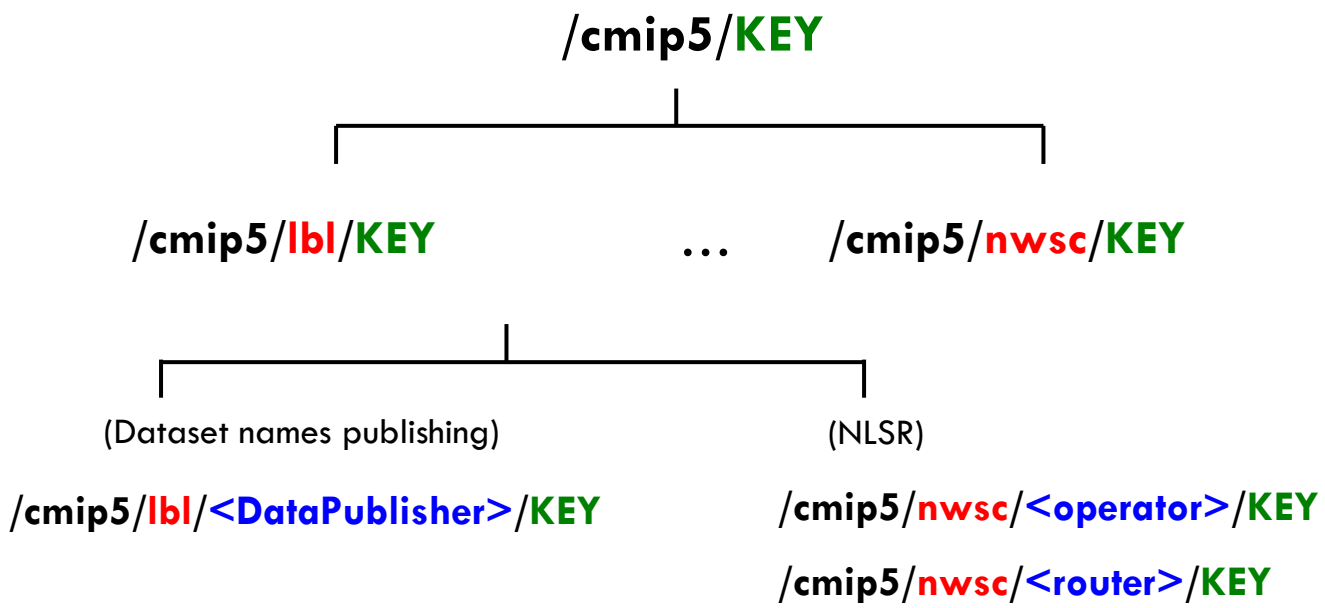
4) Fetch published name list



5) Authenticate the Data and validate data name against trust model

6) Share names with other catalogs

Keys for ndn-atmos

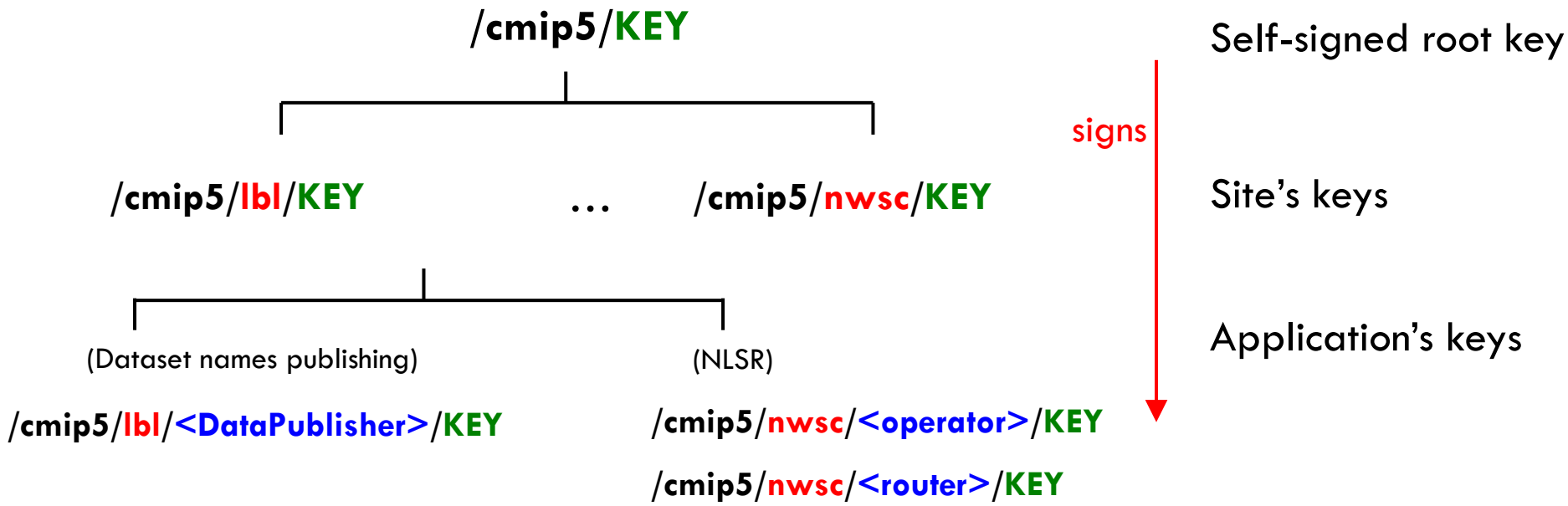


Self-signed root key

Site's keys

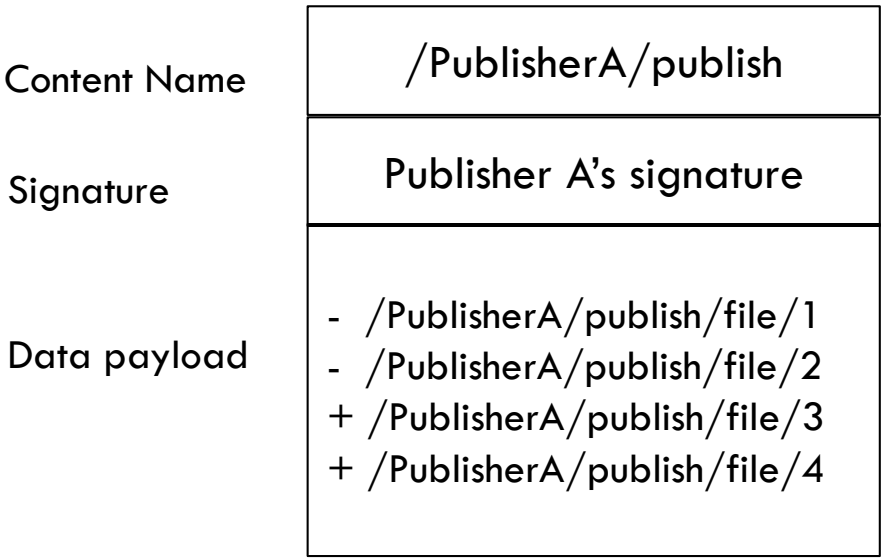
Application's keys

Keys for ndn-atmos



Trust Model

- Only namespace owners are allowed to publish data
  - Data provenance built into the data packet



Valid publish message

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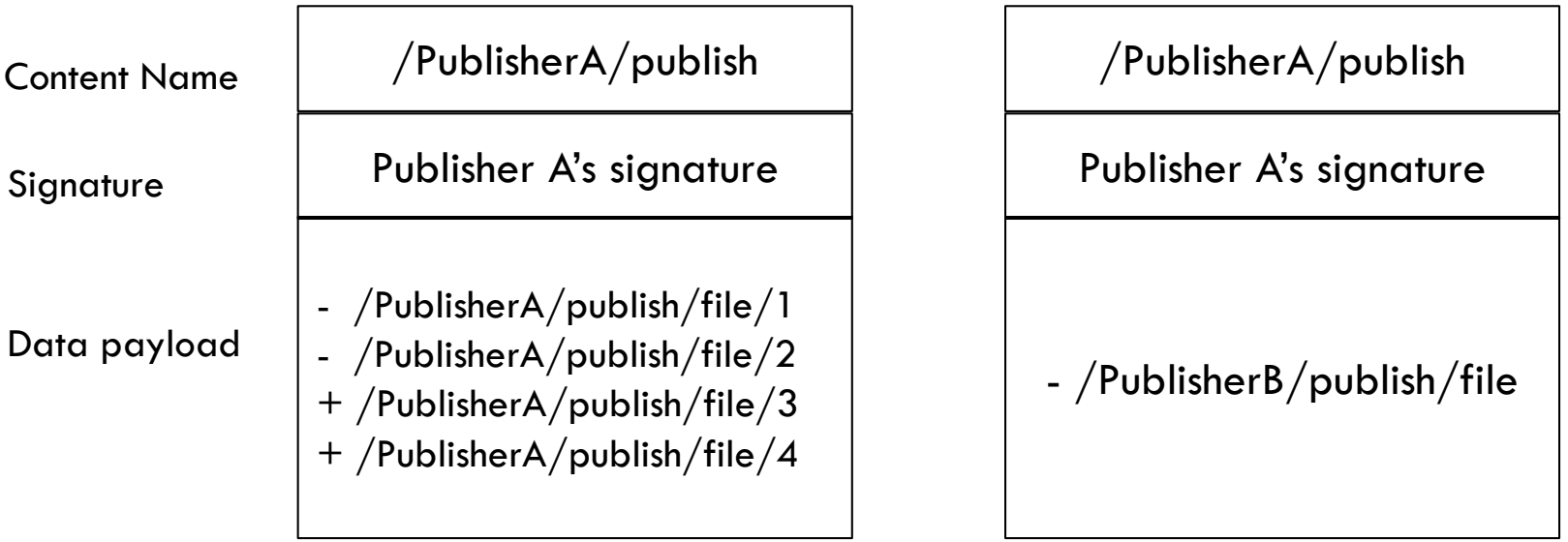

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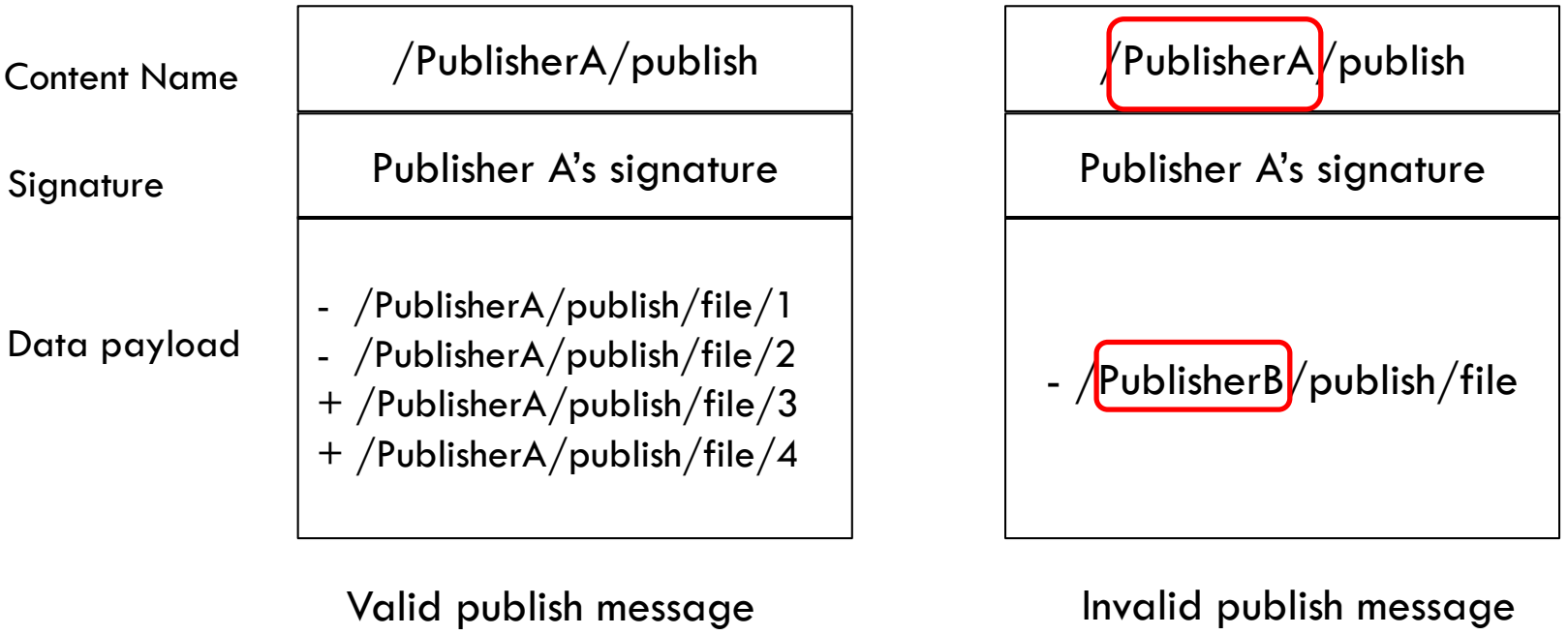

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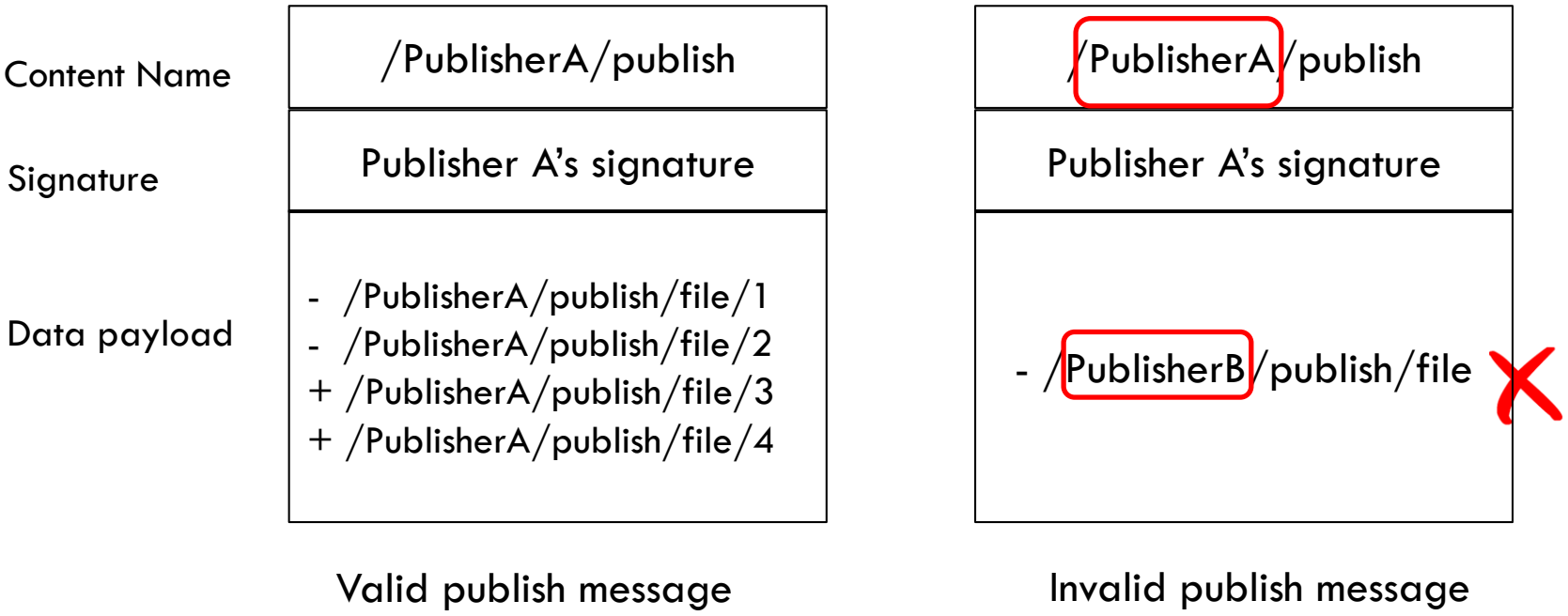

Name Discovery

Catalog

Consumer

1) Listening on /<catalog-prefix>/query

Name Discovery

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2) Query with parameters (model=cmip5 AND frequency=6hr)

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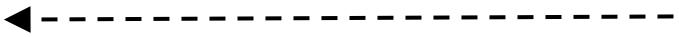

3) Query local DB; Packetize results under /<catalog-prefix>/query-results/<params>

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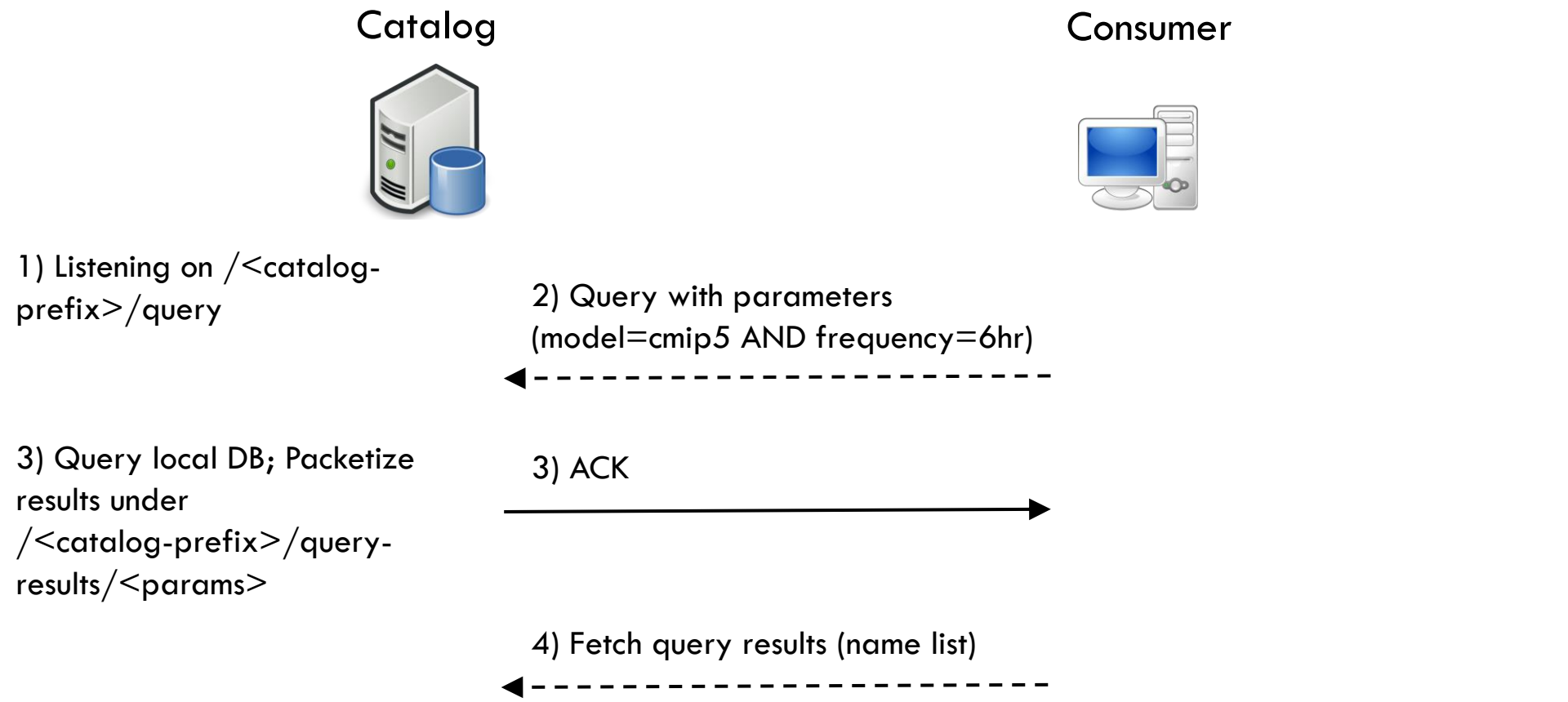

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3) ACK

4) Fetch query results (name list)

5) Fetch desired dataset(s) or re-query

Data Publication

- Catalog
  - Accept publish requests:
    /<catalog-prefix>/publish
  - Authenticate and retrieve data names from publisher
  - Sync names with other catalogs
- Publisher
  - Generate NDN names for datasets/services
  - Inform catalog of names to add/remove

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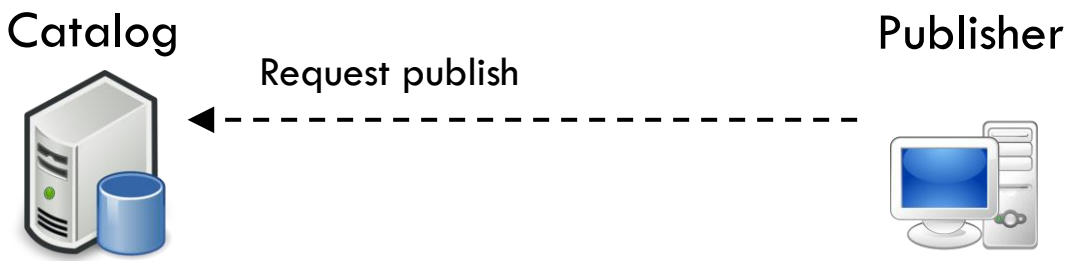

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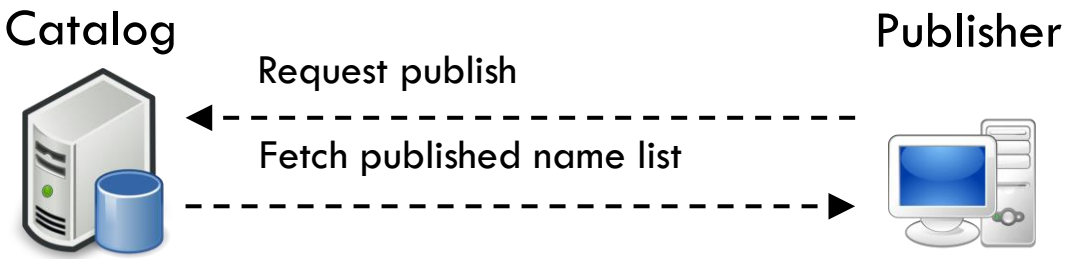

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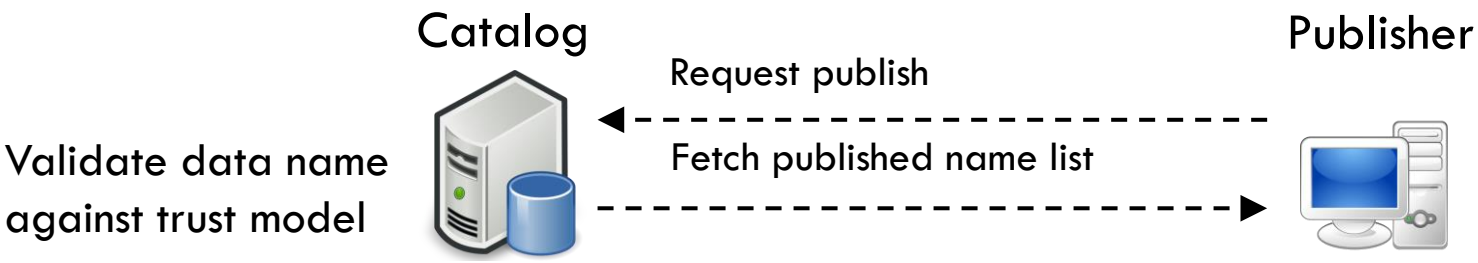

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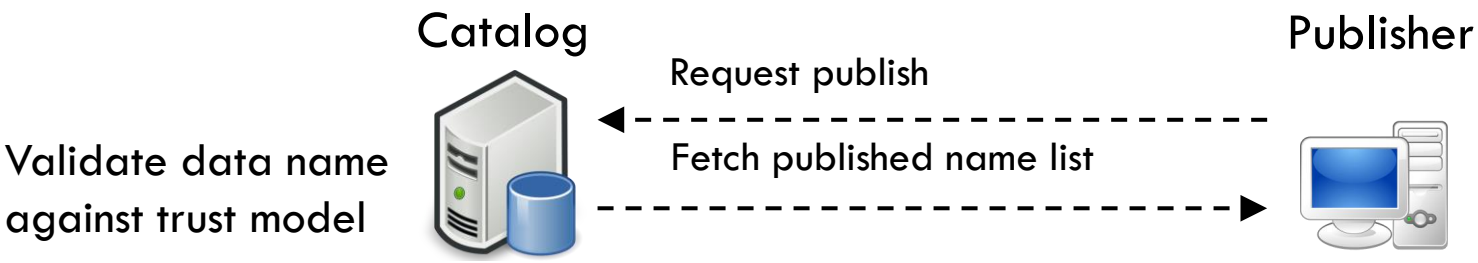

Name Discovery

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  - Accept queries on
    /<catalog-prefix>/query
  - Query local DB
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  - Query catalog for names with specified components
    - e.g.: model=cmip5 AND frequency=6hr
  - Fetch generated name list
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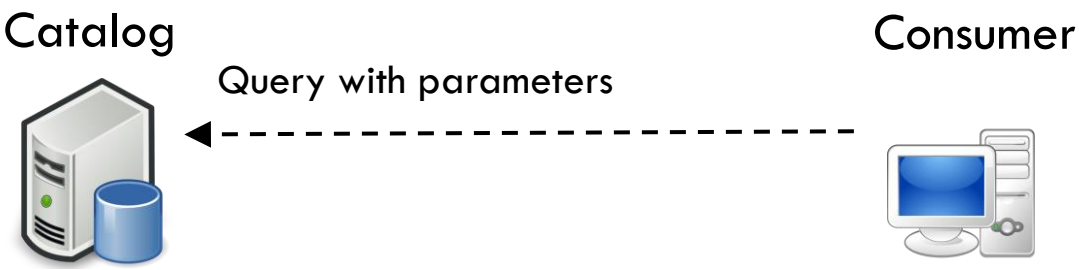

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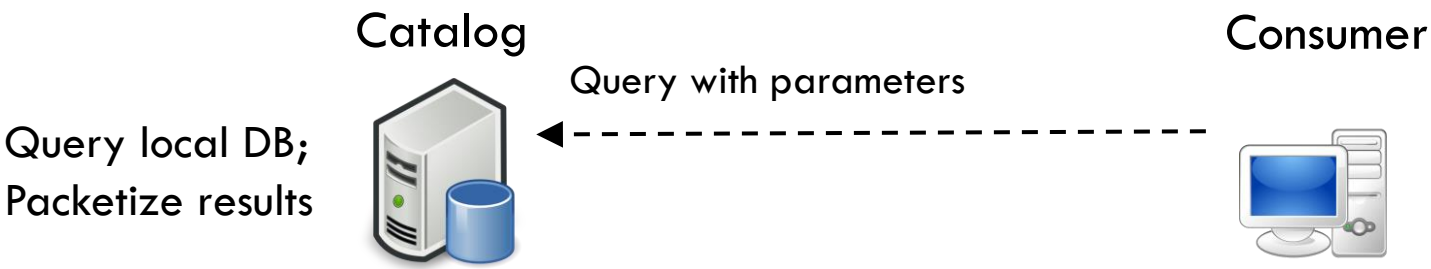

Name Discovery

- Catalog
  - Accept queries on /<catalog-prefix>/query
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  - Packetize the returned names under /<catalog-prefix>/query-results/<params>
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  - Query catalog for names with specified components
    - e.g.: model=cmip5 AND frequency=6hr
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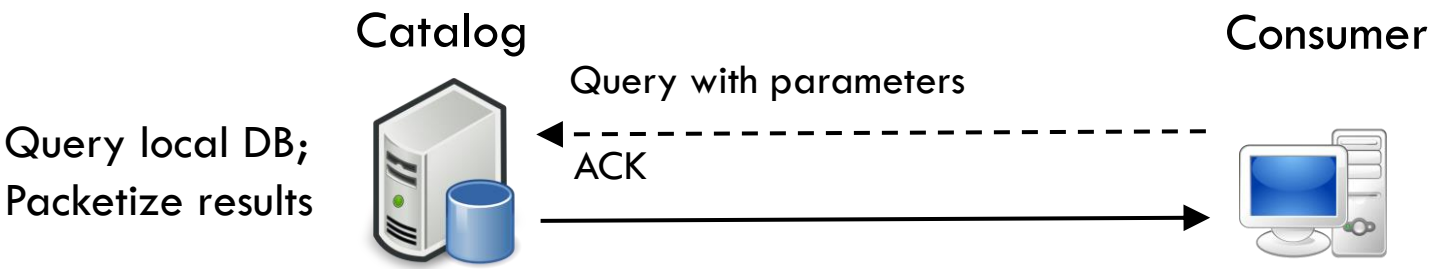

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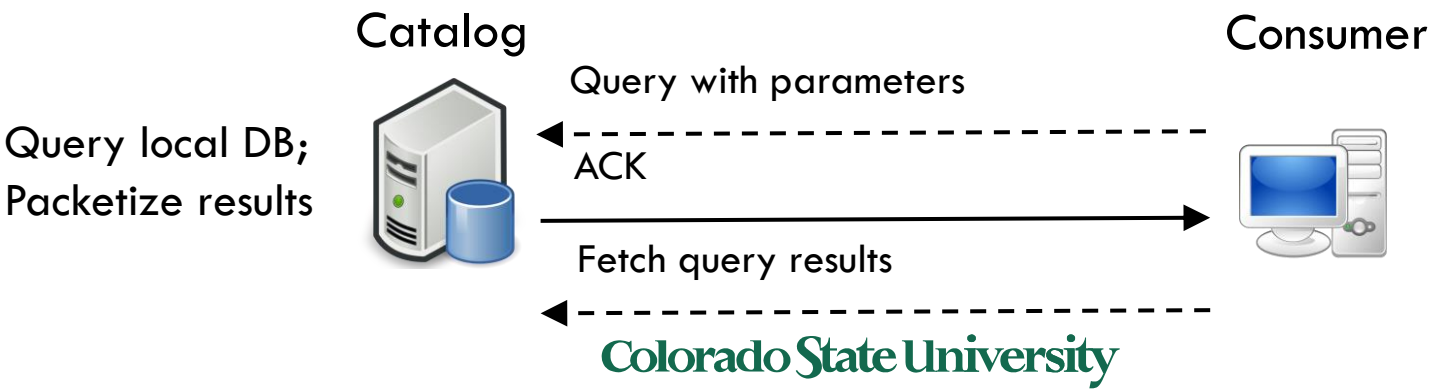

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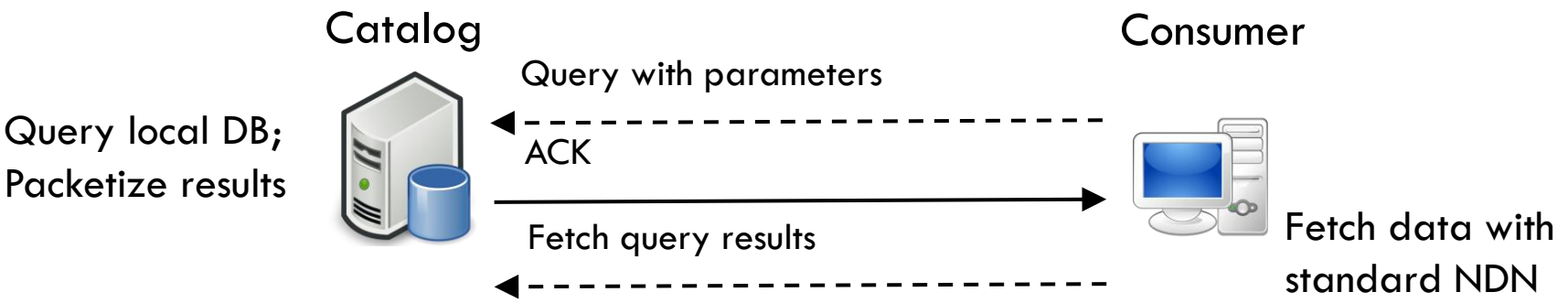


Name Discovery Optimization

- Avoid maintaining state between user and catalog
  - Enables graceful failover

- Catalog
  - Accept queries on

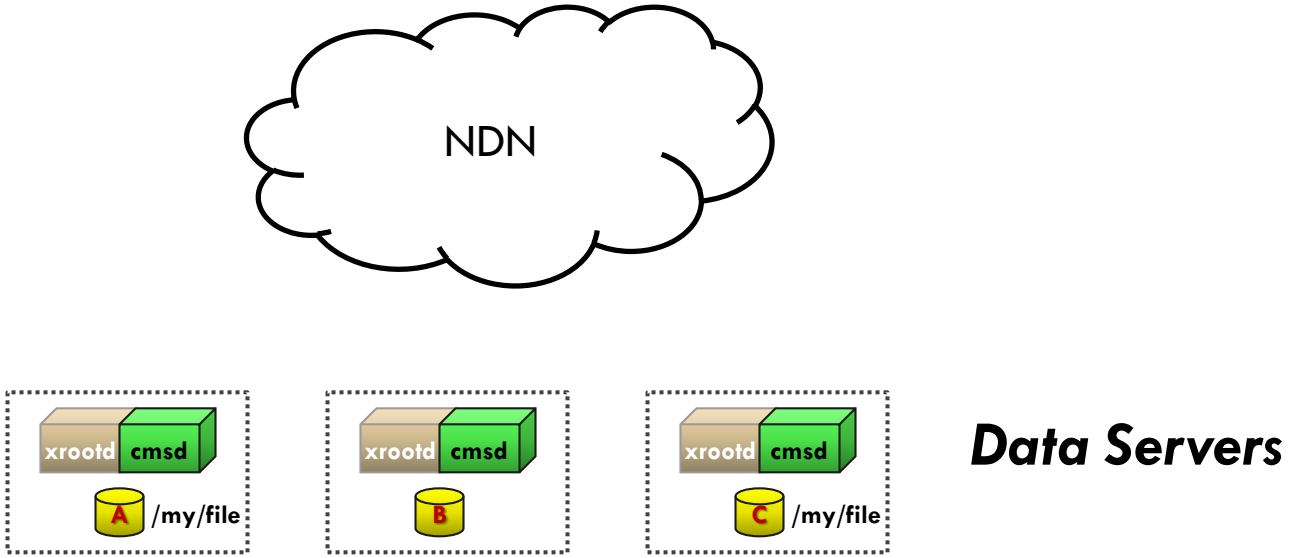
    /<catalog-prefix>/queryParams
  - Query local DB
  - Packetize the returned names under

    /<catalog-prefix>/queryParams/seg#
  - In case of failure, queries get redirected to another catalog

- Consumers
  - Can query any catalog instances
  - Can transparently failover to another catalog

Simplified xrootd Under NDN

- NDN integrates discovery, failover, retrieval …
  - Provides a better abstraction to the applications



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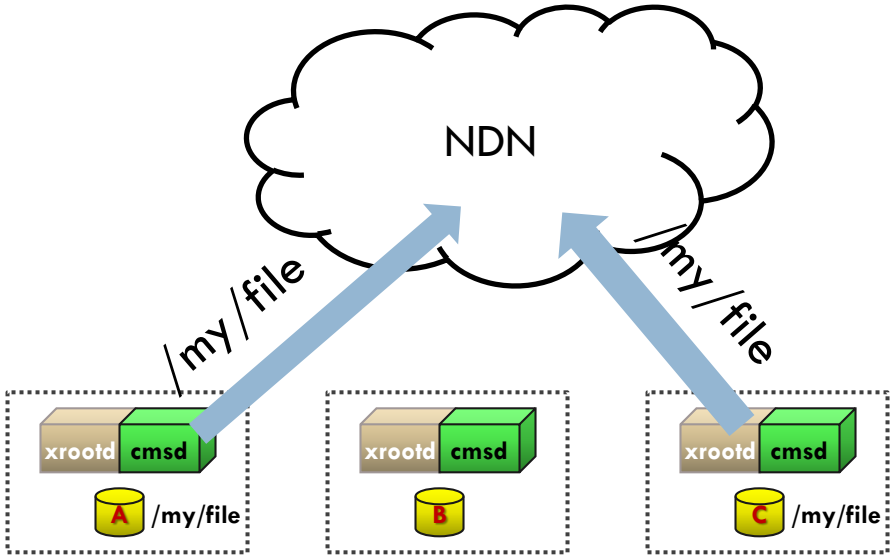

Data Servers

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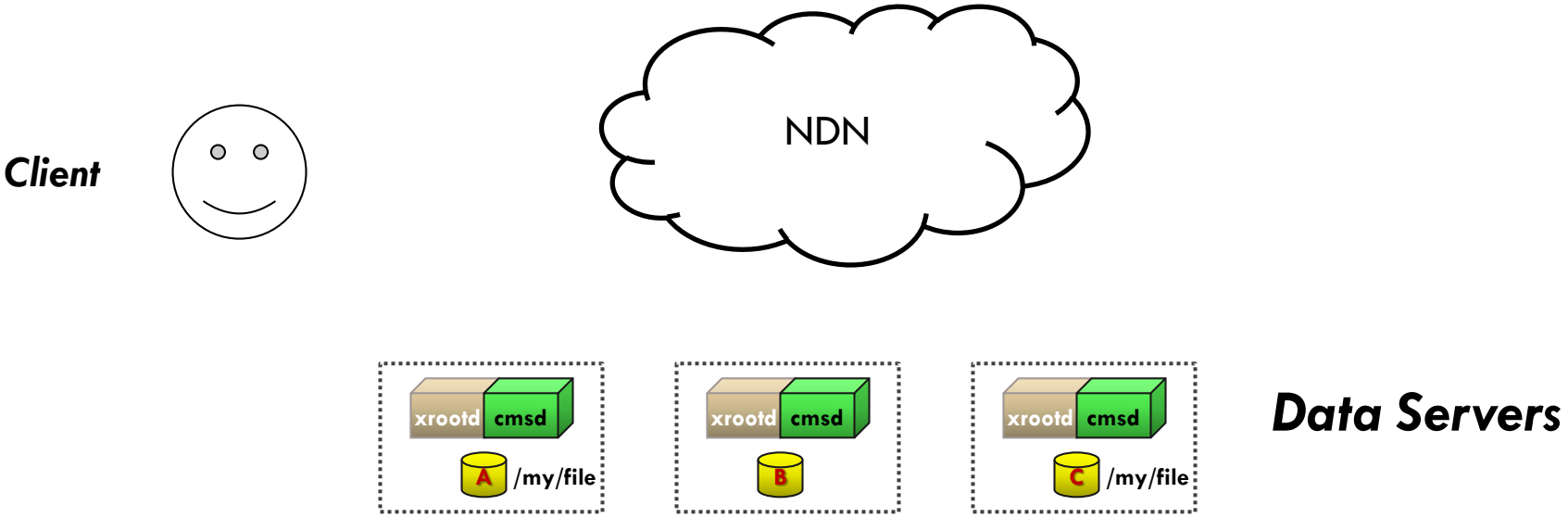

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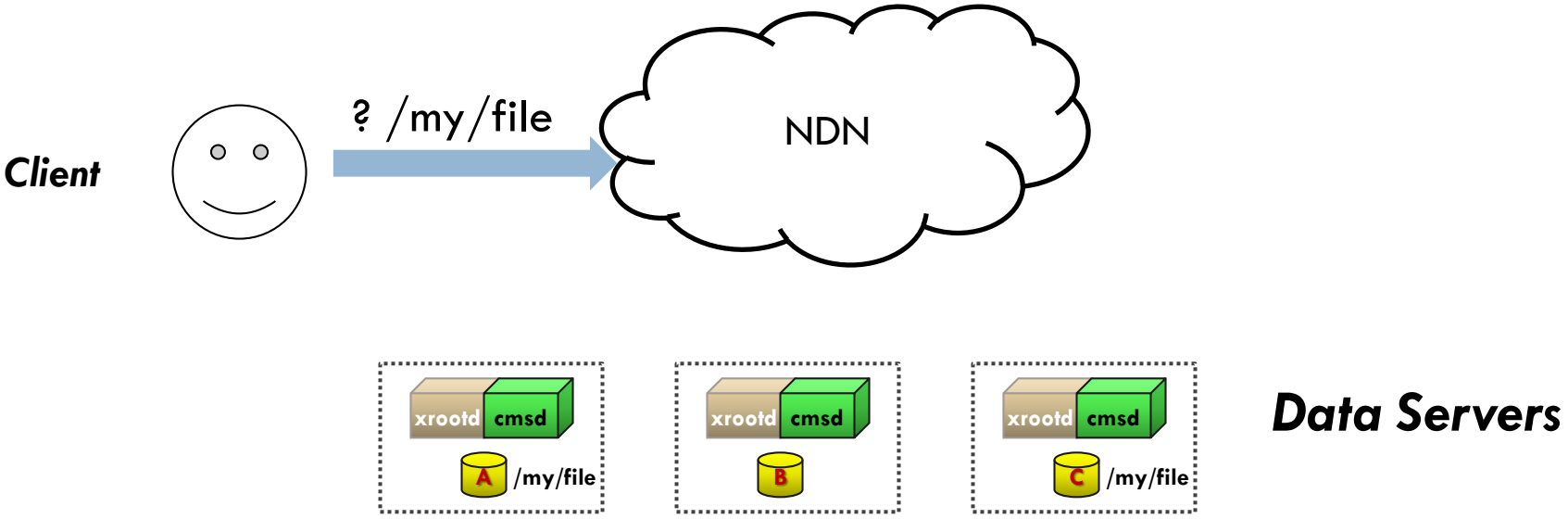

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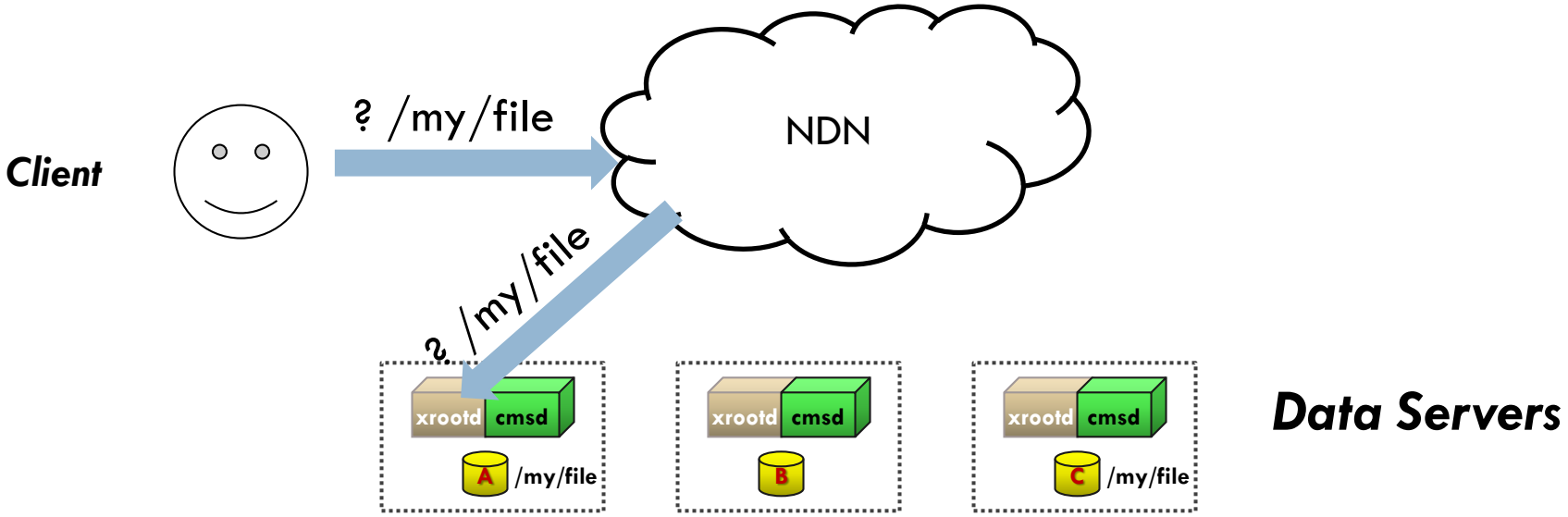
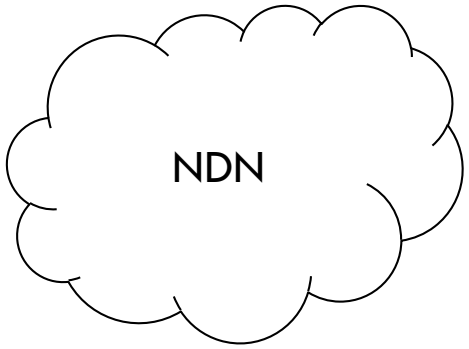


Name Discovery Challenges

- Users may need to discover content/services without knowing a the full NDN name prefix structure
  - NDN names are contiguous prefixes
  - Users may only know a few disjoint name components (e.g. frequency=6hr)
  - But can not use wildcards for name discovery

User wants: /CMIP5/output1/VA/6hr/2016



. . .

Consumer

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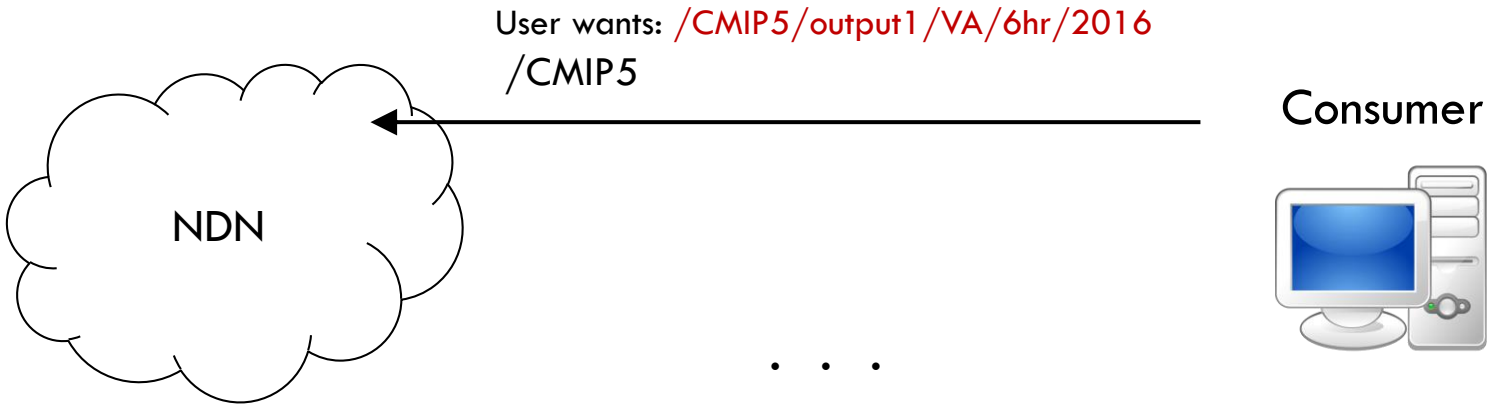

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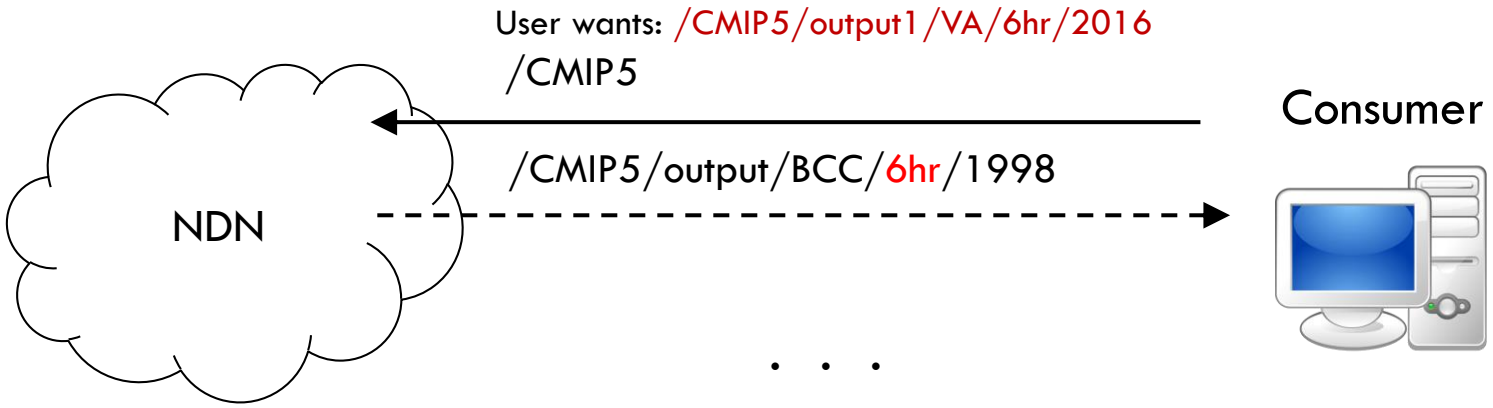

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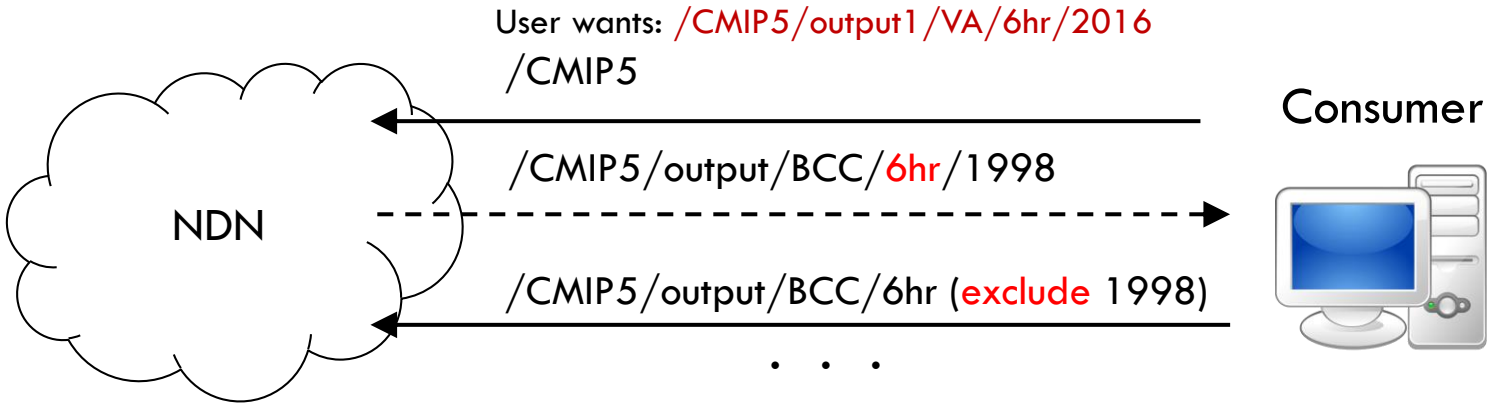

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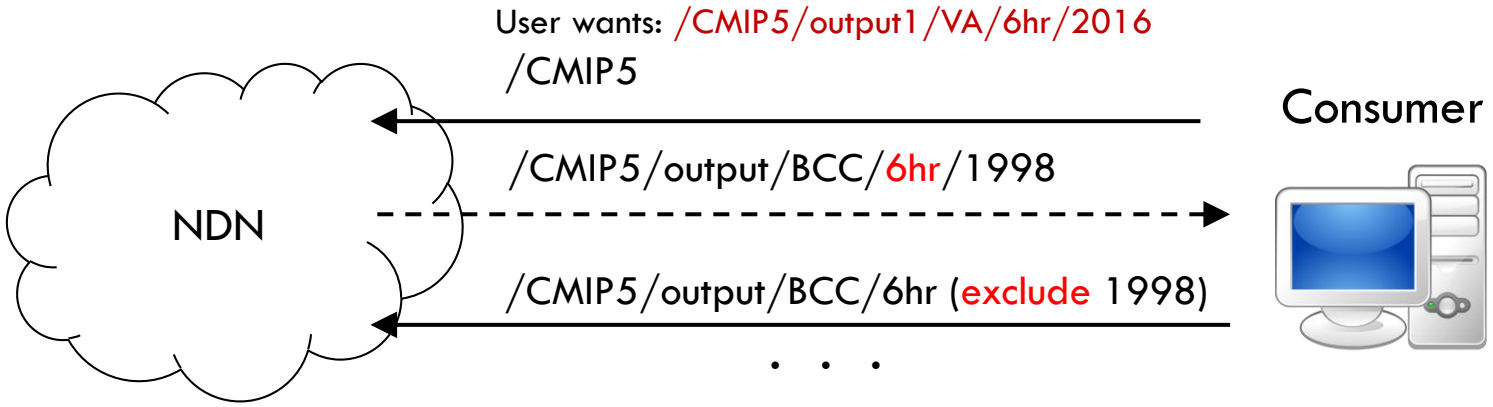


May take too many requests to find desired data or service

NDN Support for Big Science

- NDN Names separate data from hosts
  - Discovery: Names directly translate to network queries
  - Failover: Network can get verifiable data from anywhere
  - Retrieval: Data can be fetched from optimal source(s)

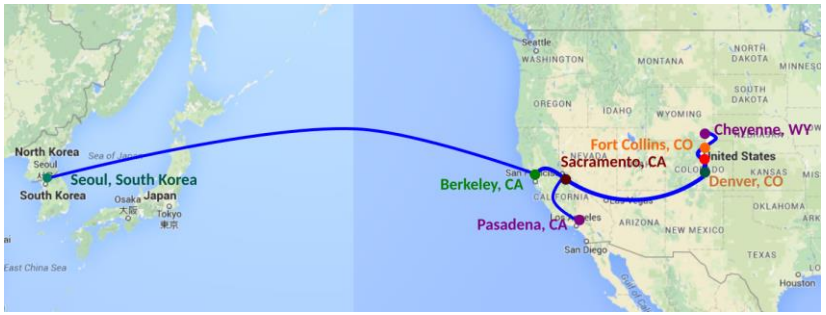
- Investigate the use of NDN as a platform for scientific data applications
  - Understand data management challenges of various scientific domains
  - Develop prototype applications to leverage NDN's built-in features
  - Use these applications as case studies to drive NDN research aspects

Summary

- NDN improves scientific data management at scale
  - Apps benefit from transparent multipath, automatic failover, etc.
  - Built-in security provides publisher provenance
- Names are the common building block for content and services
  - Names are flexible: can refer to static content or dynamic services
- Catalog supports efficient publication, non-contiguous name discovery
  - Users can discover content and services with minimal a priori knowledge
  - Catalog validates publication requests for authorization

Managing Scientific Data with NDN

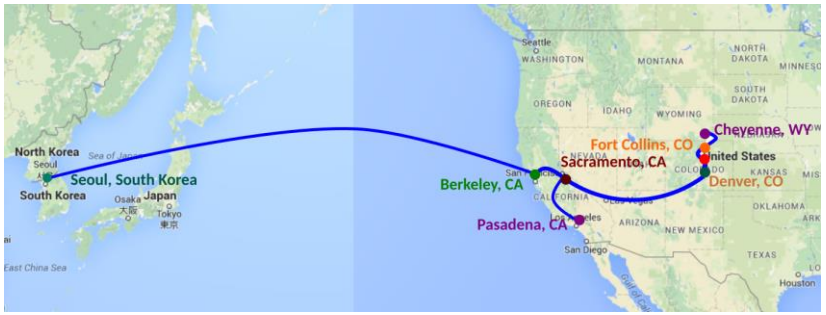
- Distributed, synchronized catalog of names and services
  - Common functionality: publishing, discovery, access control, etc.
  - Search and retrieval UI
  - Platform for further research and experimentation
- Research questions:
  - Namespace construction, distributed publishing, key management, UI design, failover, etc.
  - Functional services such as subsetting
  - Mapping of name-based routing to tunneling services (VPN, OSCARS, MPLS)



- Science testbed
  - 10G testbed (courtesy of ESnet, UCAR, and CSU Research LAN)
- Nodes strategically located near scientific data (climate +HEP)
- CC-NIE NSF award

Managing Scientific Data with NDN

- Name-based Internet architecture
  - Name the data, not the host
  - All data digitally signed
  - Unifies and pushes common functionality to the network: publishing, discovery, access control, etc.
- Data Intensive applications
  - Automatic pervasive in-network caching, parallel retrieval, automatic failover and more
  - Simpler alternative middleware implementation e.g., ESGF, xrootd



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