# Supporting Autonomous Networking with Content Centric Networking

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Computing Science

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# Autonomous Networking should be…

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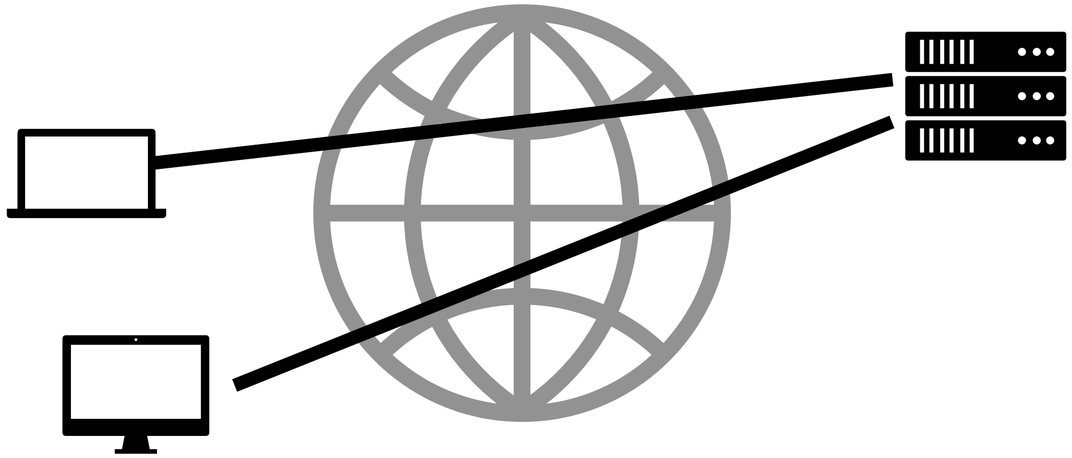
- Self-managing
  - No need for a complex address provisioning
  - No need for complex routing configuring
  - Enable dynamic resource re-allocation
- Self-healing
  - No need for manual intervention to restore connectivity after recovering lower-layer disruption

# Protocols in the current Internet and Socket Communication

## Standard IP-based networking:

Point-to-Point



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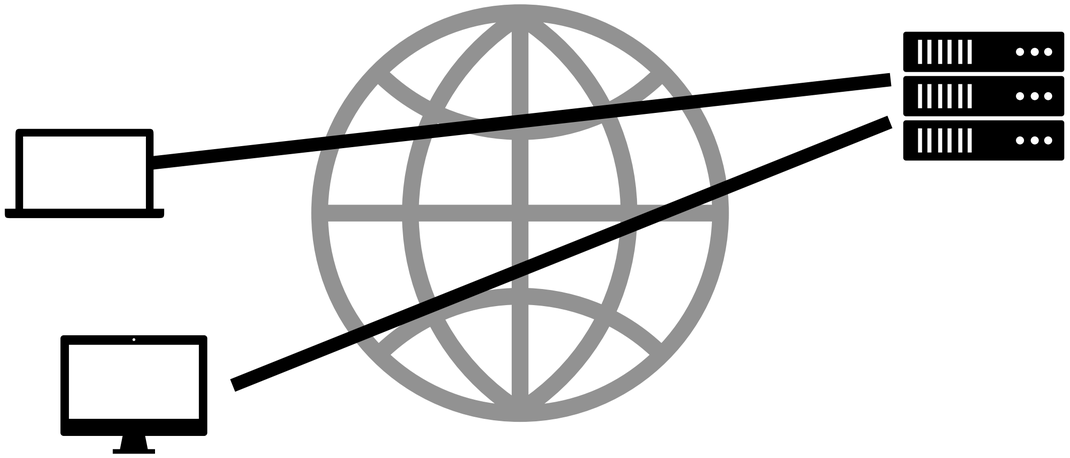

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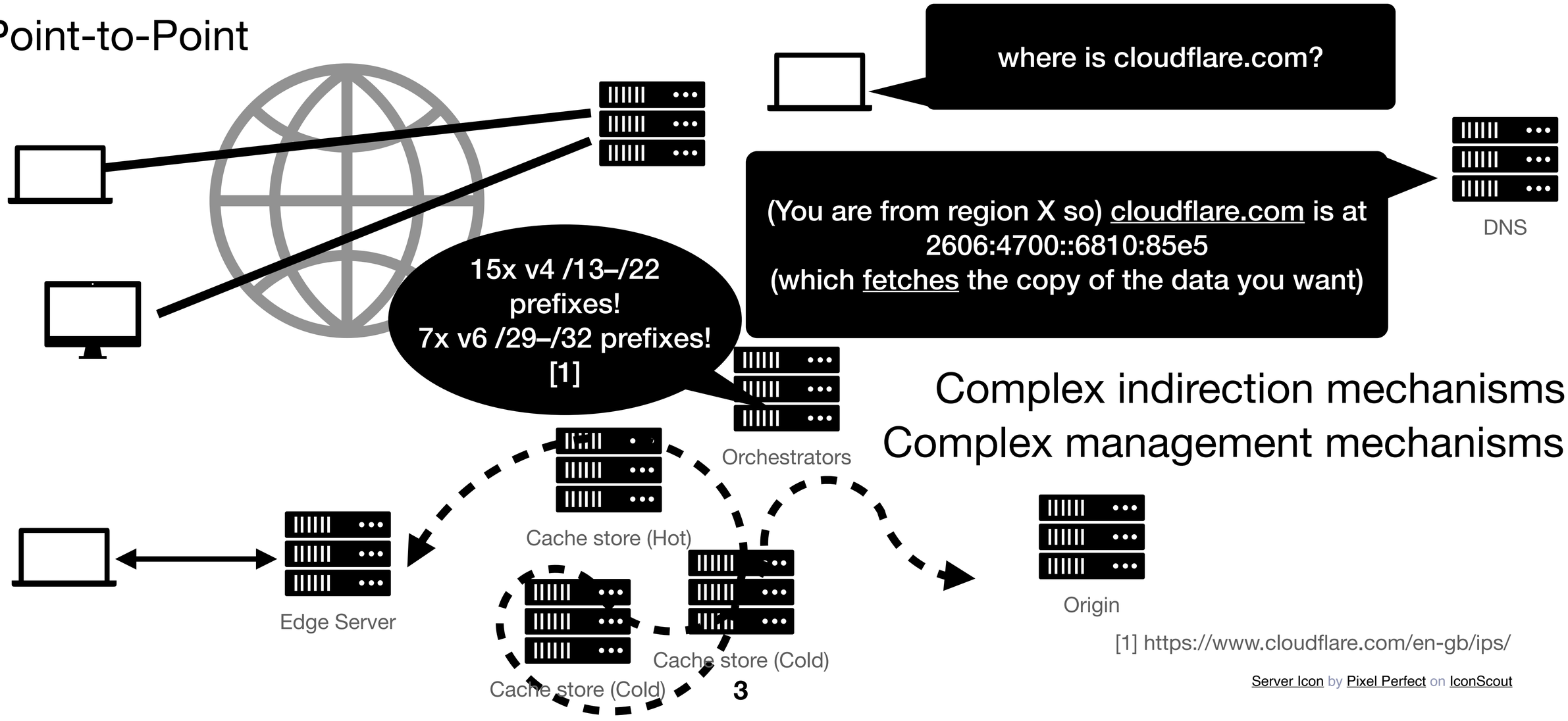

# Background

## What changed and what hasn't?

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**The way we use the Internet has changed since the early phase of the Internet ~1990s:**

- Communication model:
  - Point-to-point connection-oriented end-to-end model —> data-oriented
  - e.g. P2P distributed file-sharing, Emergence of CDN w/ distributed caches
- Computing model:
  - Static -> Dynamic
  - Static on-premise servers -> dynamically provisioned Cloud/Edge infrastructures
  - e.g. SDN, Containerisation, orchestration etc.

**these complex mechanisms are needed because of IP based networking**

# Barriers in enabling dynamic infrastructure

- Users want the data or the service, not the ‘connection’
  - Any change in the user location or the server location breaks the connection, therefore breaking the communication session
- Operators want to reallocate resources dynamically
  - Management is complex
    - **Address management:** allocation and reassignment
    - **name-address mappings** and re-mapping (for dynamic deployment)
    - **cache management:** placements, updating, pointing to the right cache

# Content Centric Networking (CCN) / Information Centric Networking (ICN)

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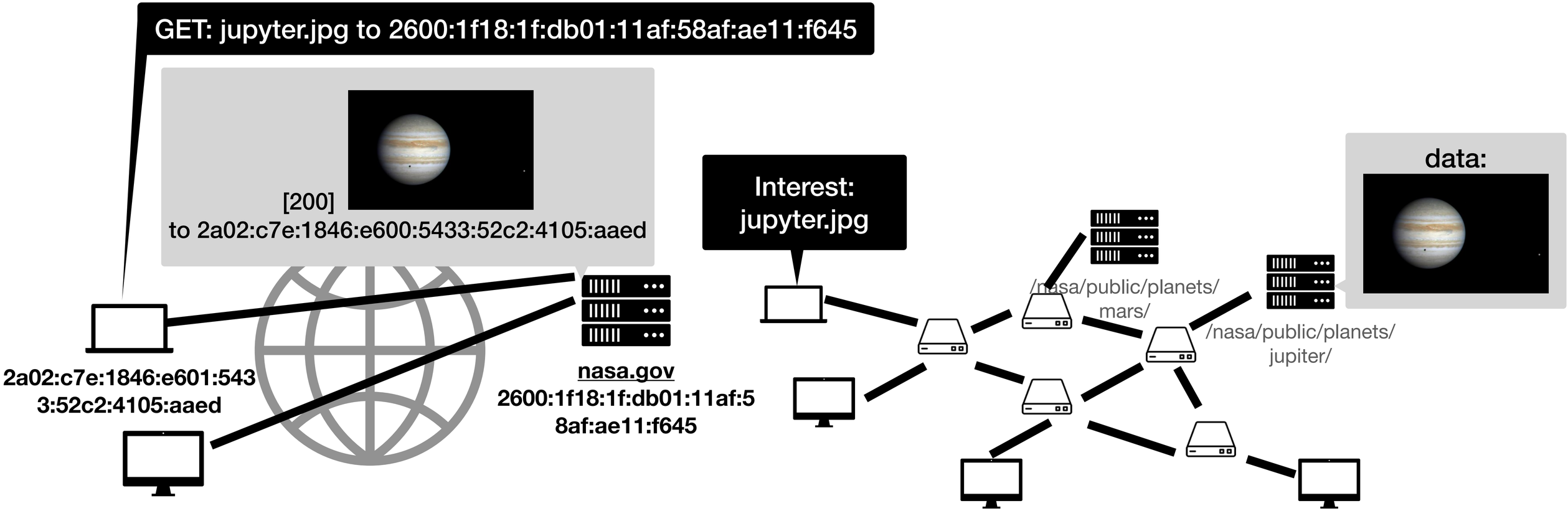
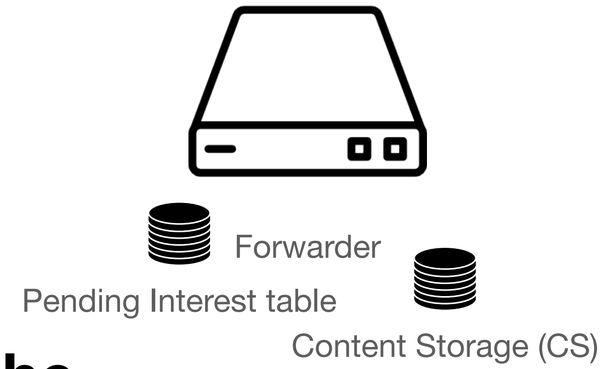
- **Not** a socket communication; forget TCP/UDP/QUIC



# Content Centric Networking (CCN) / Information Centric Networking (ICN)

- **Not** a socket communication; forget TCP/UDP/QUIC
- **Name** of the data/content/information is the **primary identifier**
  - **No IP address**
- Two types of packets: **Interest** and **Data**
- CCN/ICN network consists of **forwarders**:
  - **Content Store** — Previously forwarded data, **on-path cache**
  - **Pending Interest table** — Pending requested names + direction they came from
  - **Forwarding Information Base** — Which directions to forward the interest



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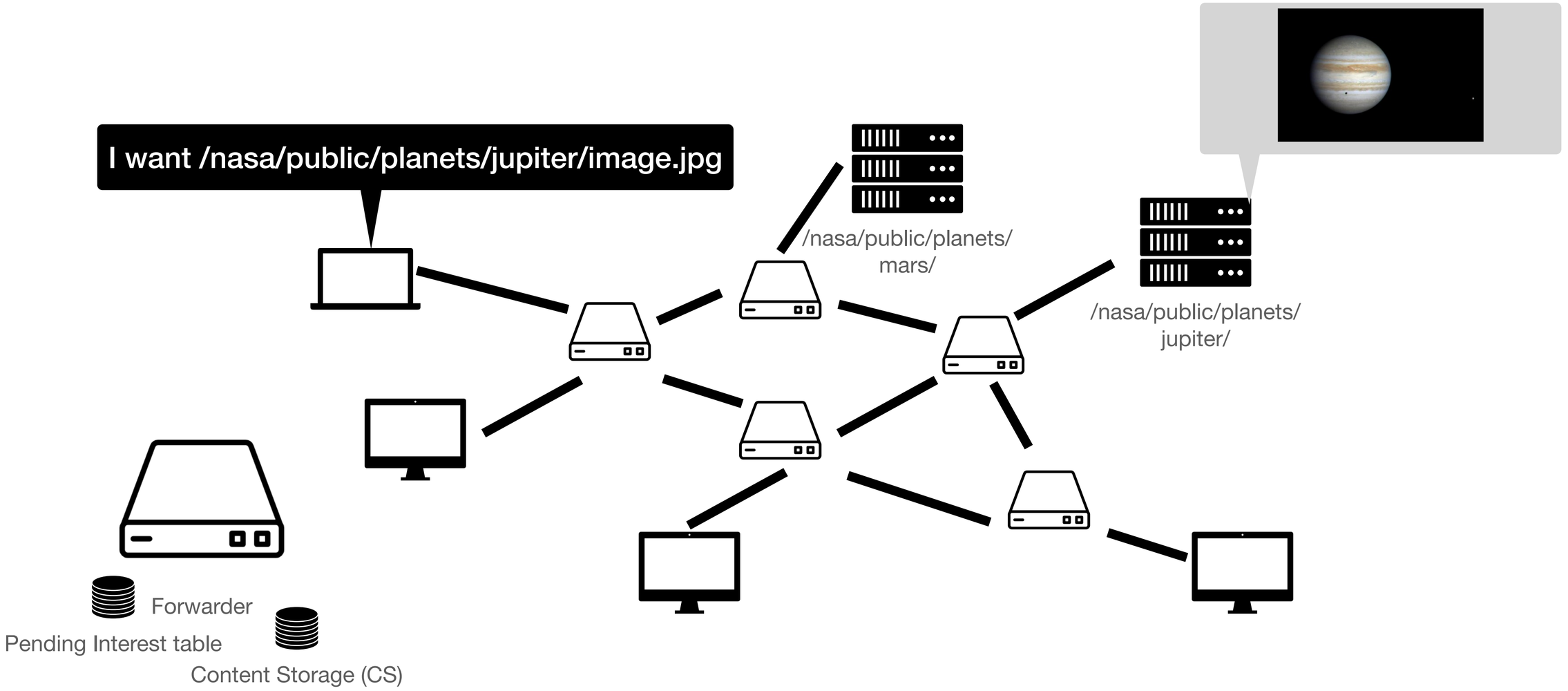


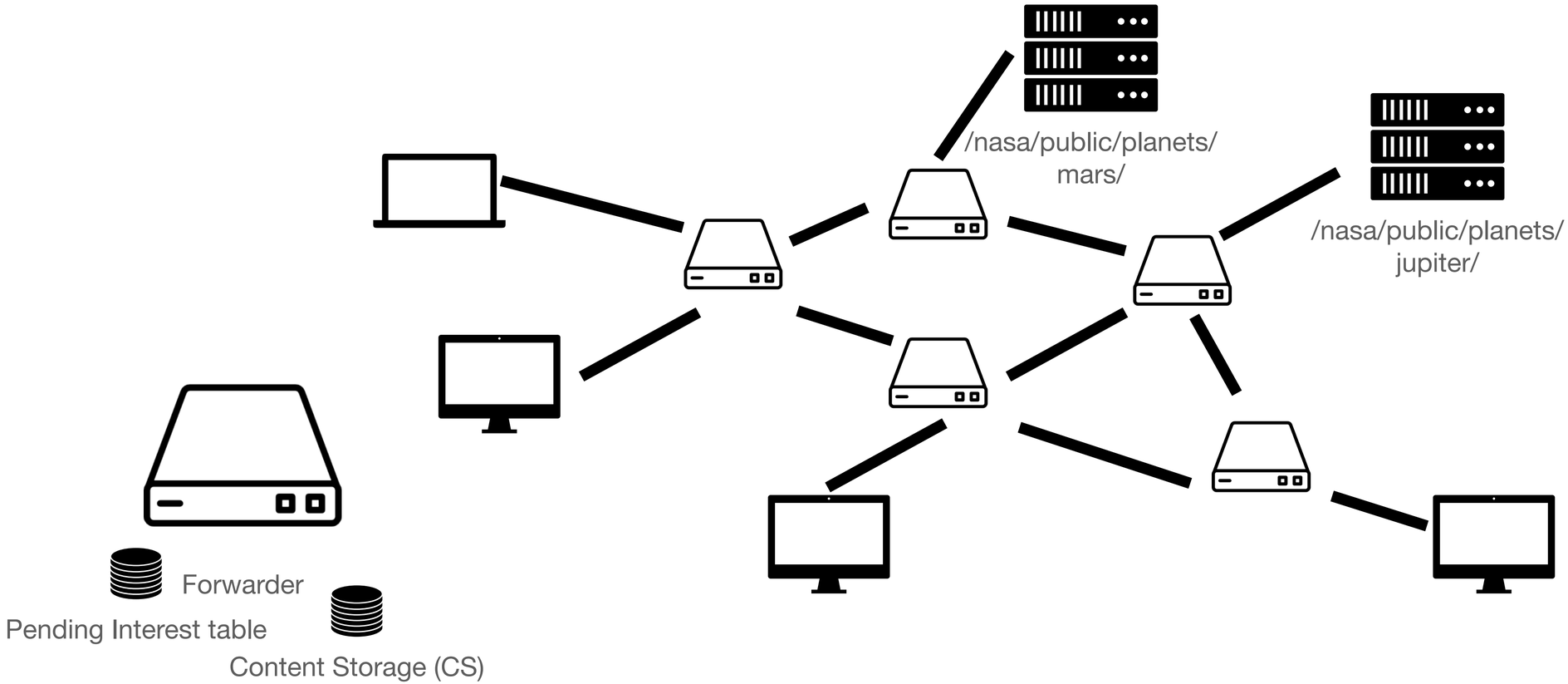
# Content Centric Networking (CCN) / Information Centric Networking (ICN)

## General operation

1. A host requests a data by sending an **Interest packet**
2. Request is forwarded to the neighbouring **forwarder**
3. **Forwarder** will check if it already has the data
    3.1. Reply with the **data packet** if it has a copy
    3.2. Continue if it does not
4. Record the **Interest and the ‘direction’ the interest came from**
5. Forward the interest packet to a neighbouring forwarder (hopefully reaches the **producer** of the data and replies with the data)
6. Upon **receiving the data**, if it matches the pending interest name, **forward to the direction the interest came from**

# Content Centric Networking (CCN) / Information Centric Networking (ICN)

## Walk through



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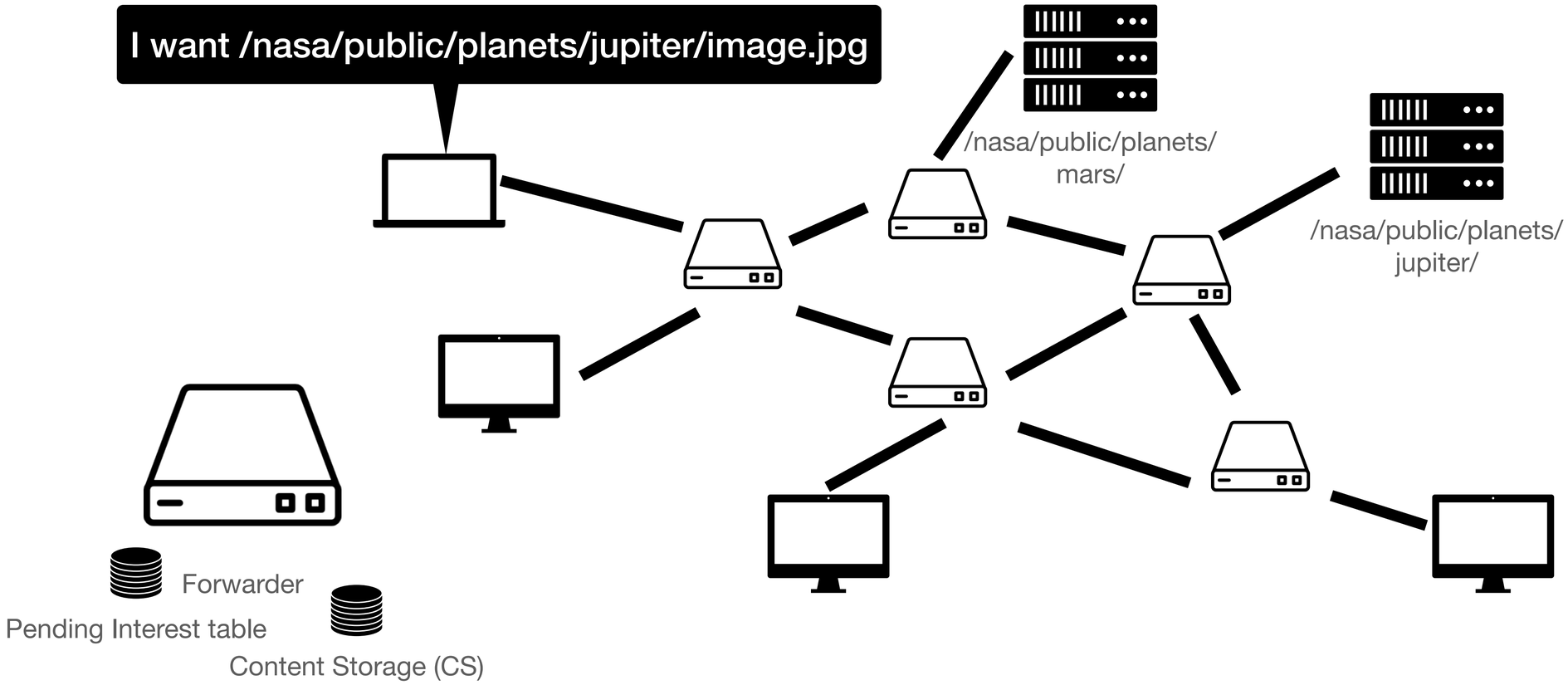

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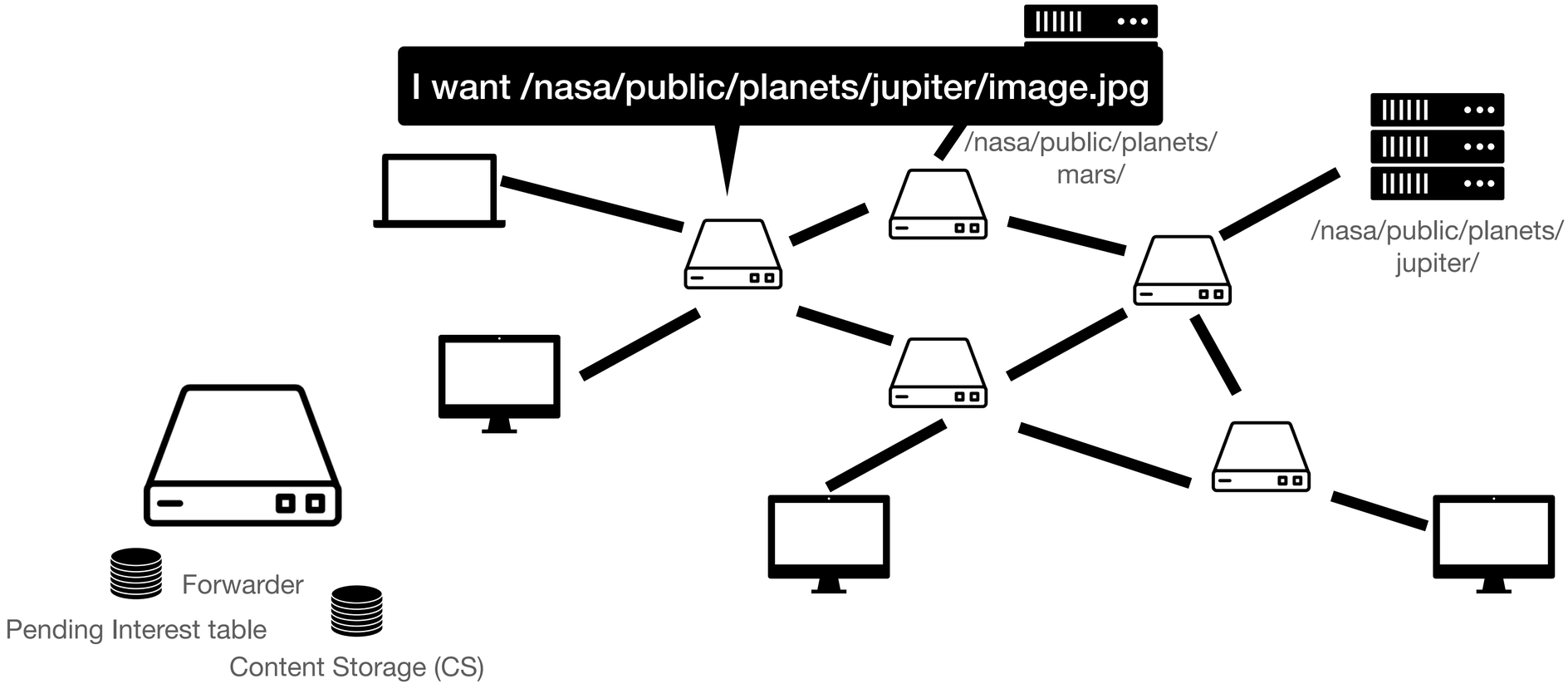

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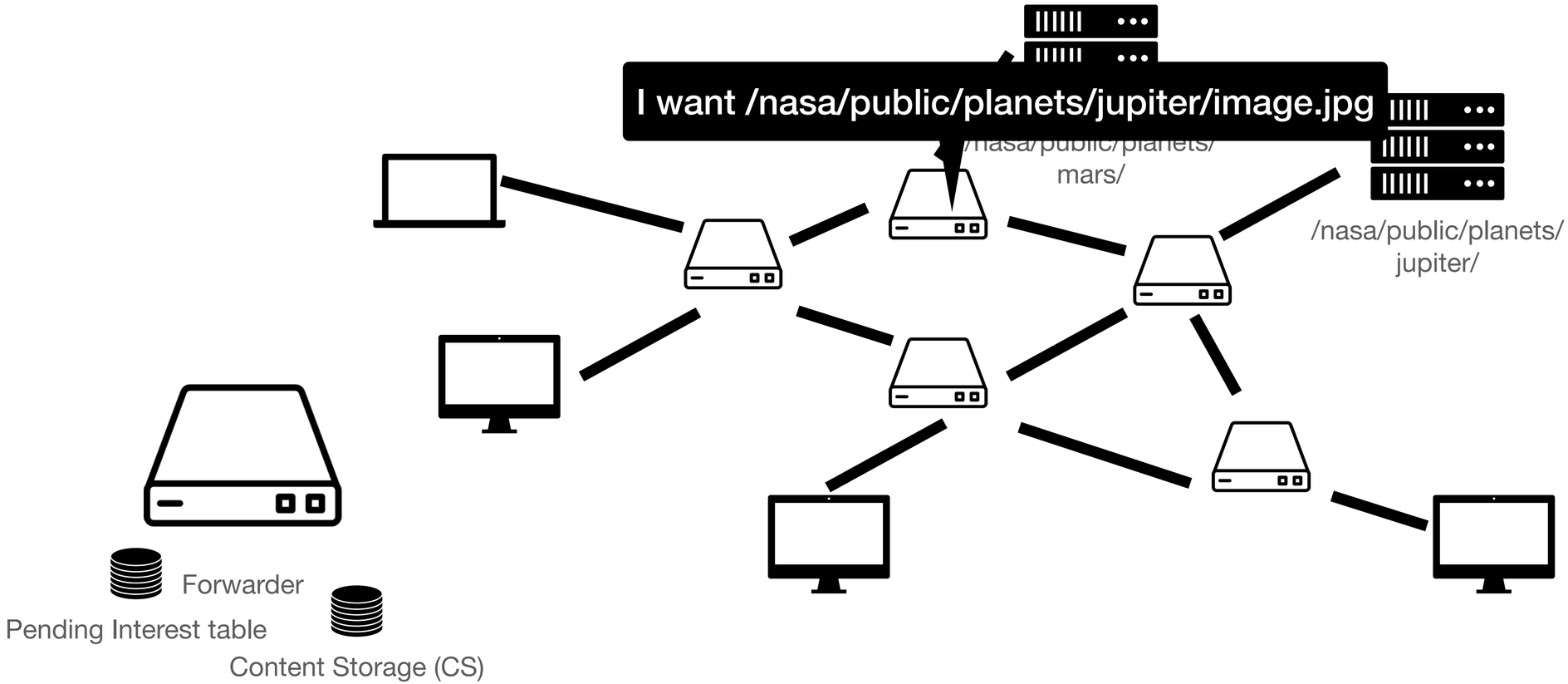

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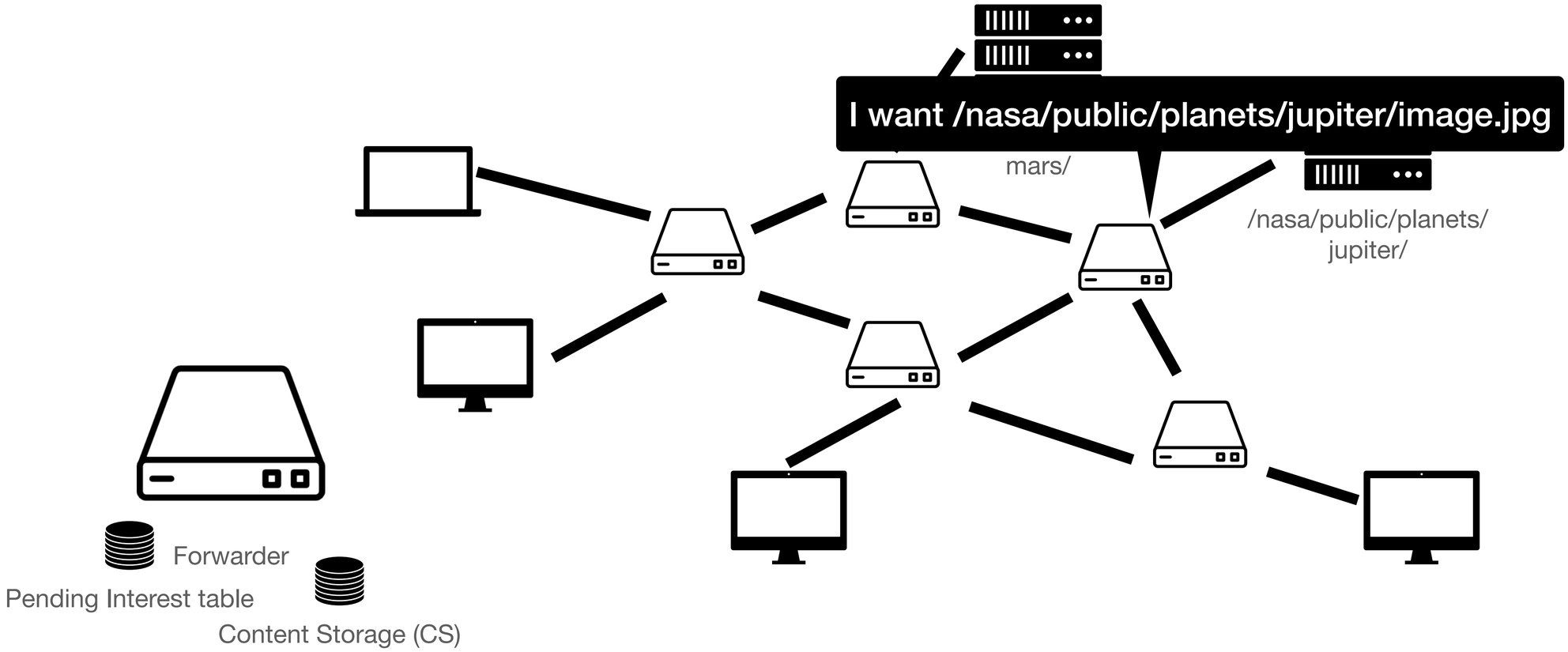

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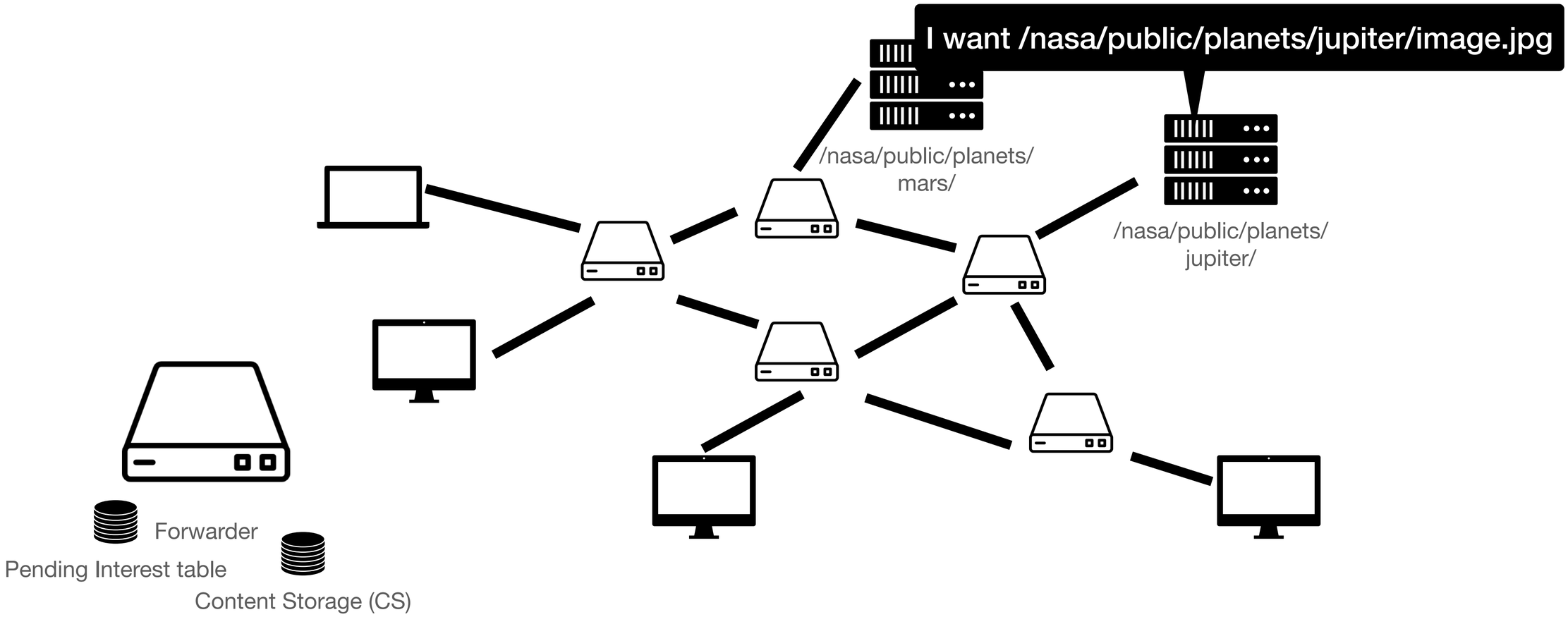

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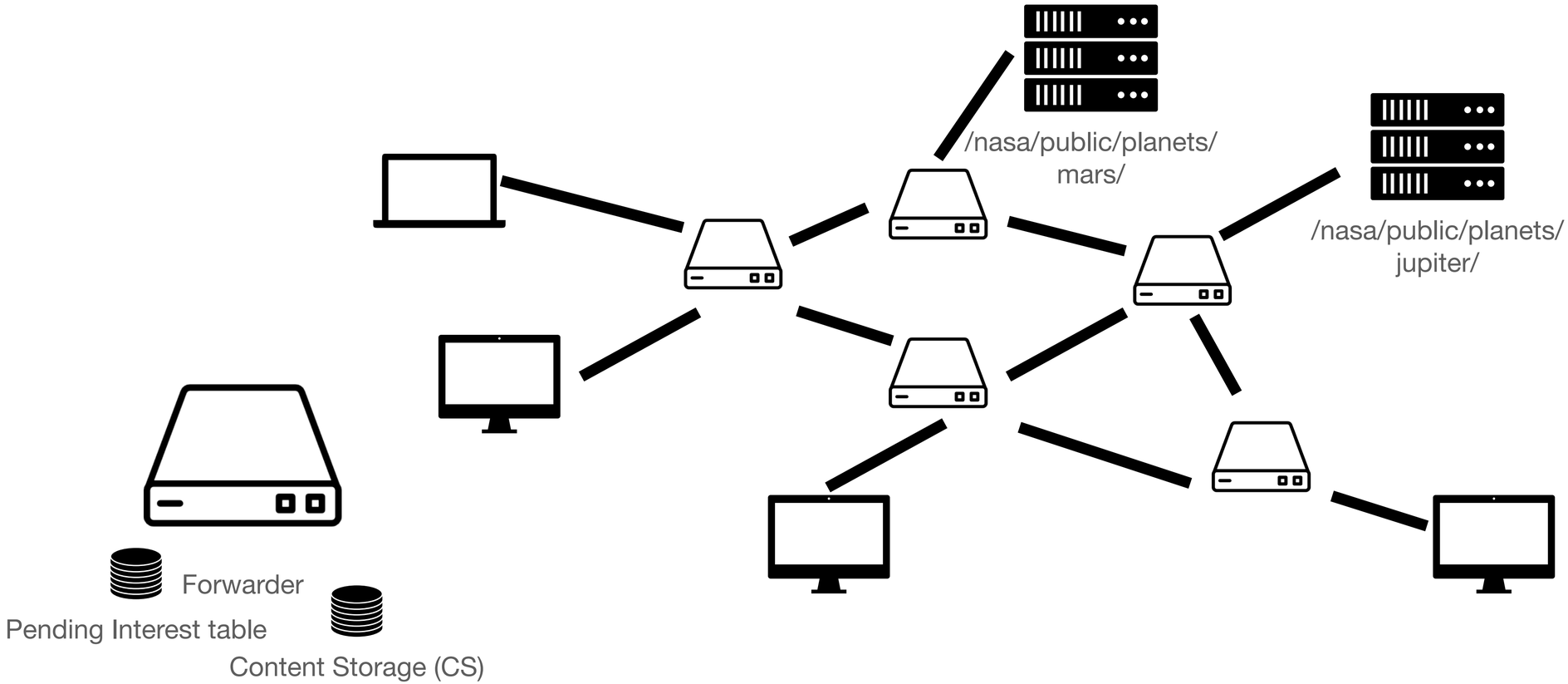

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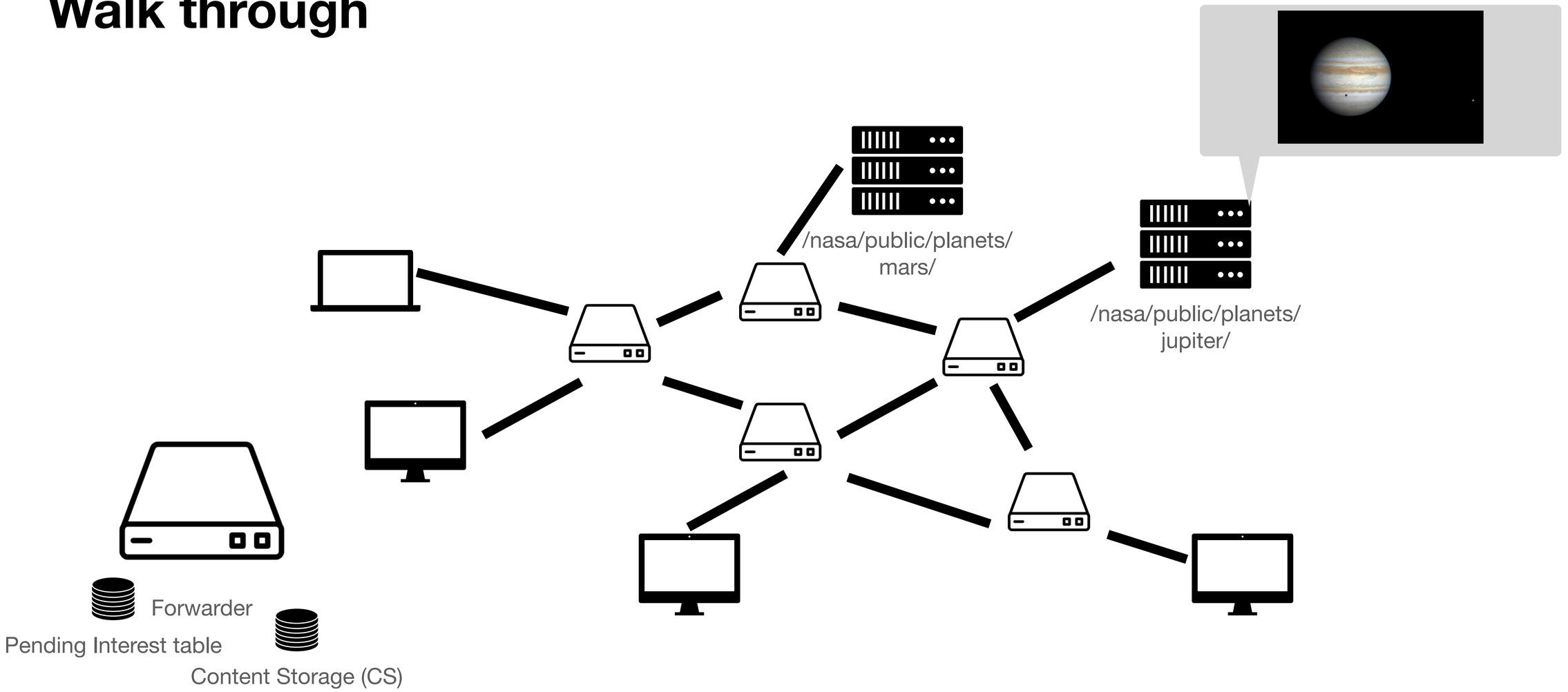

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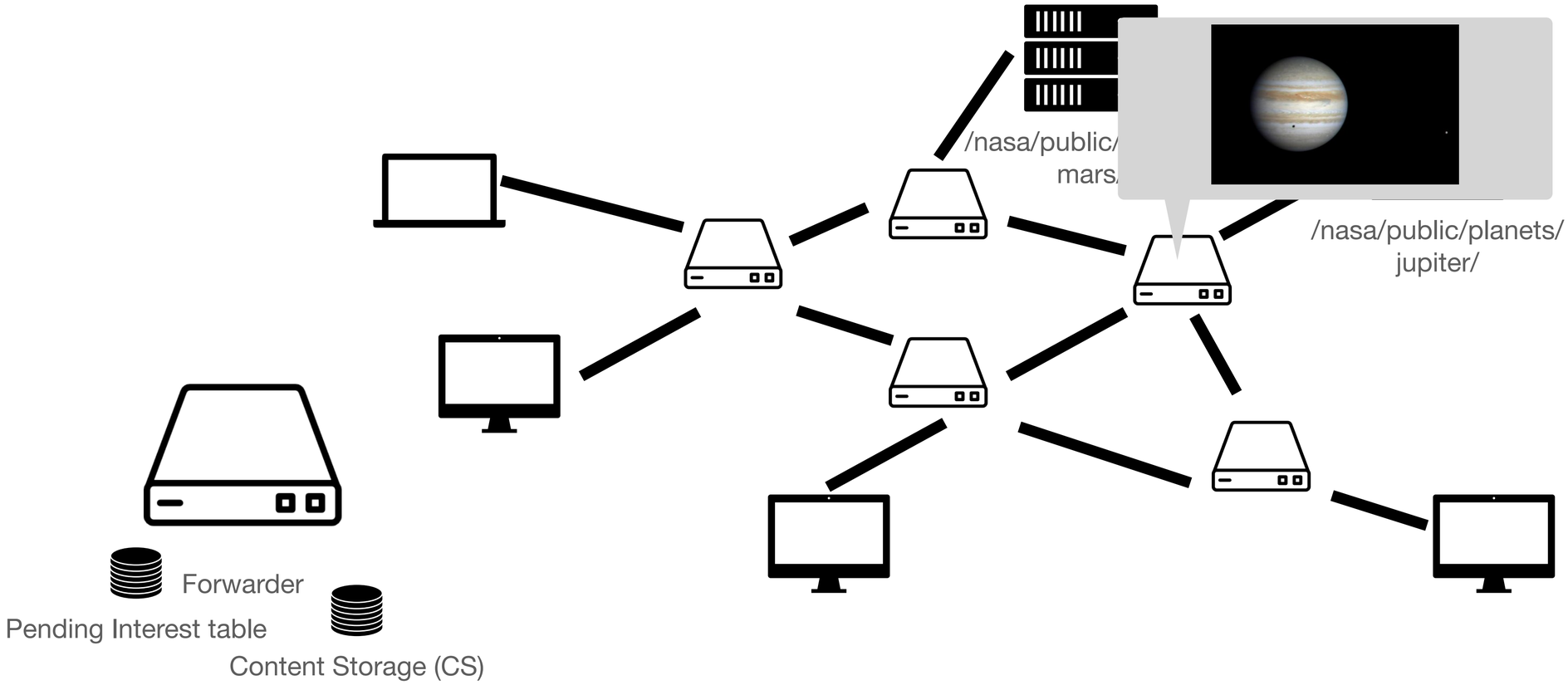

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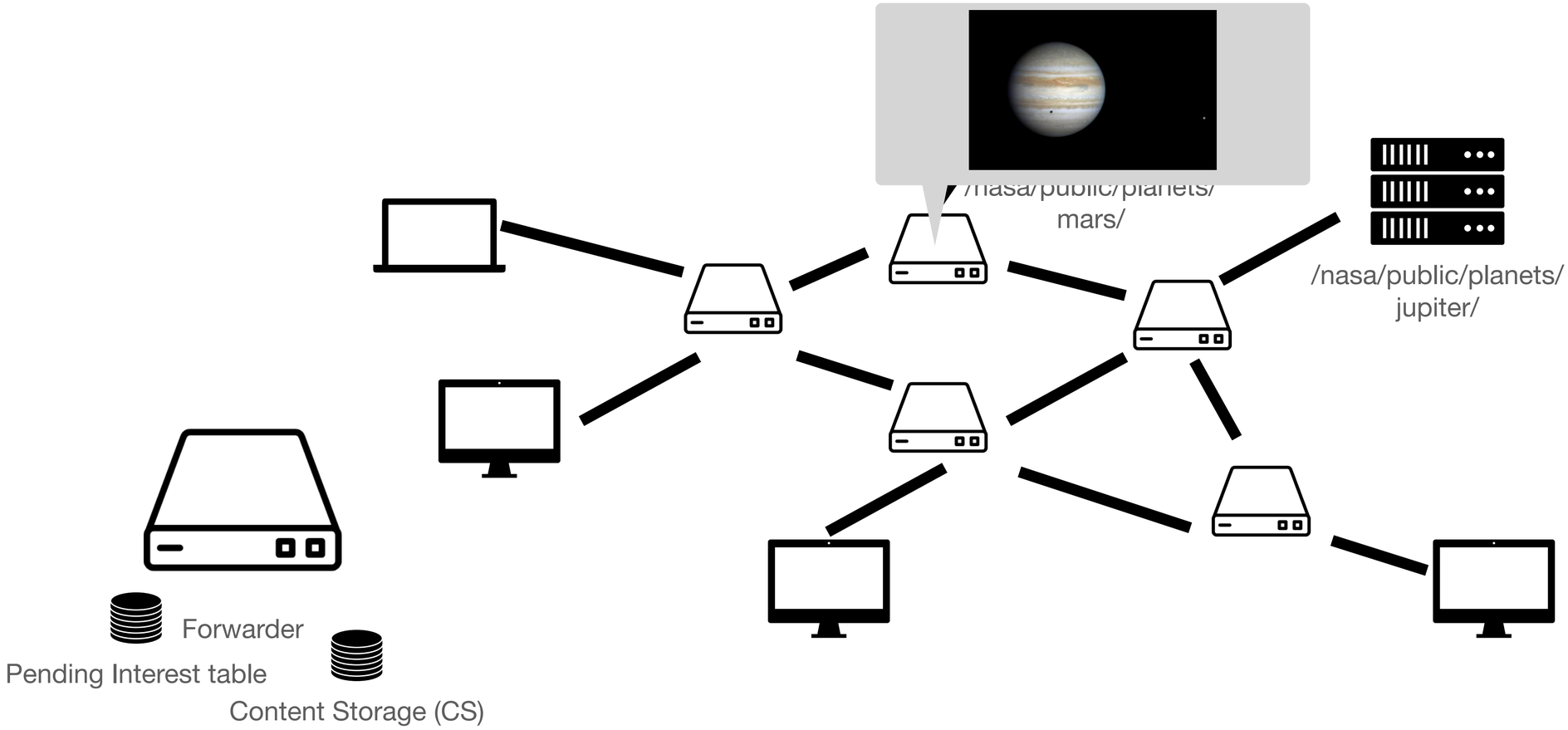

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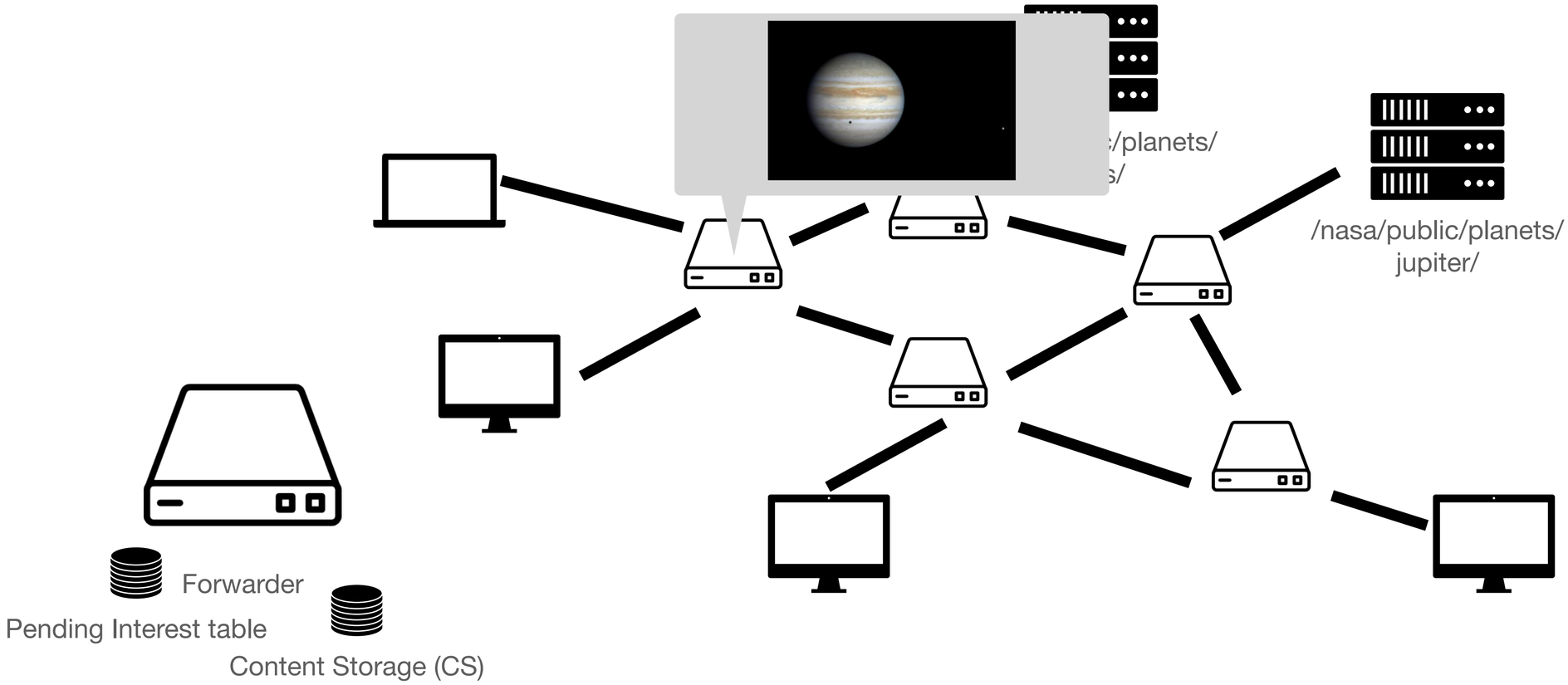

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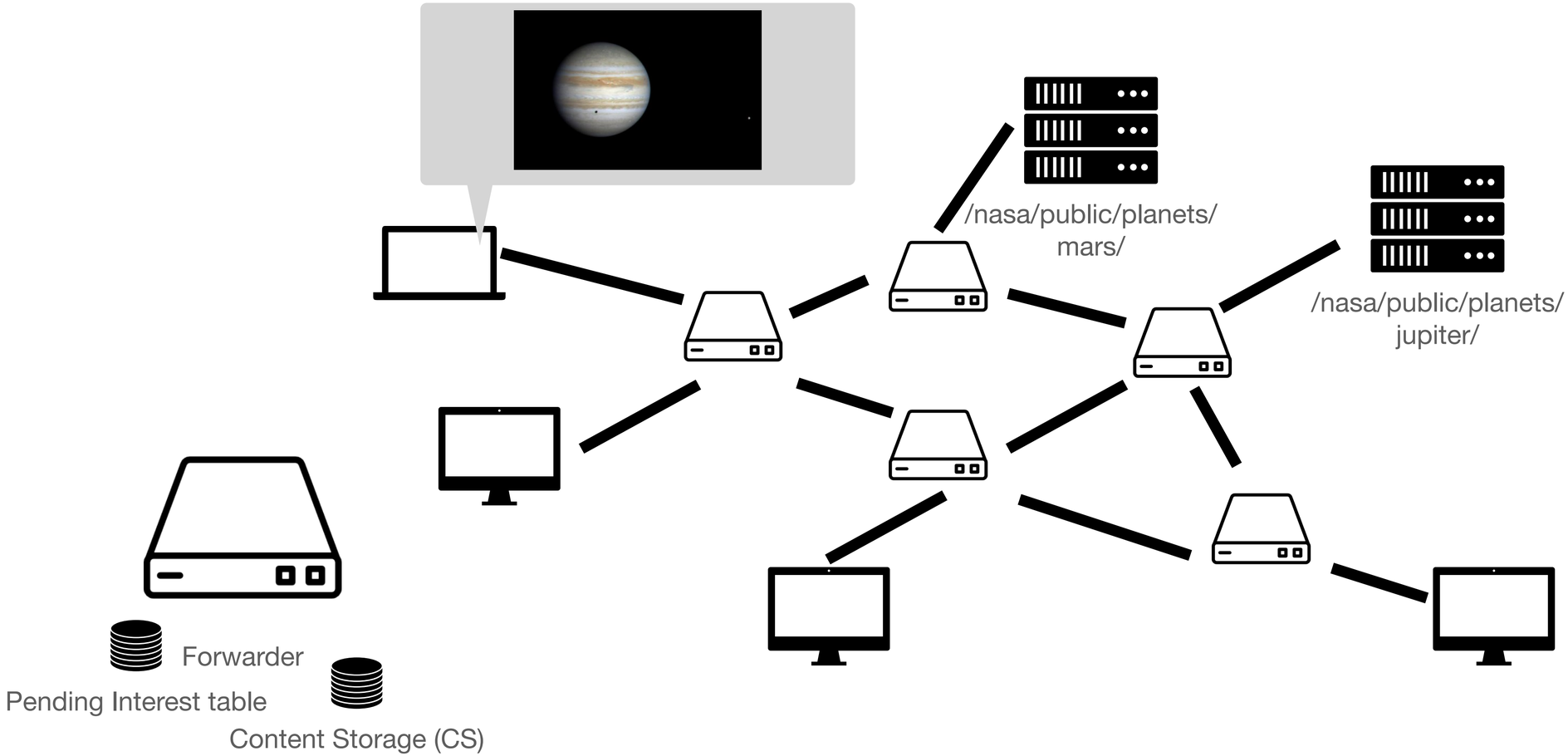

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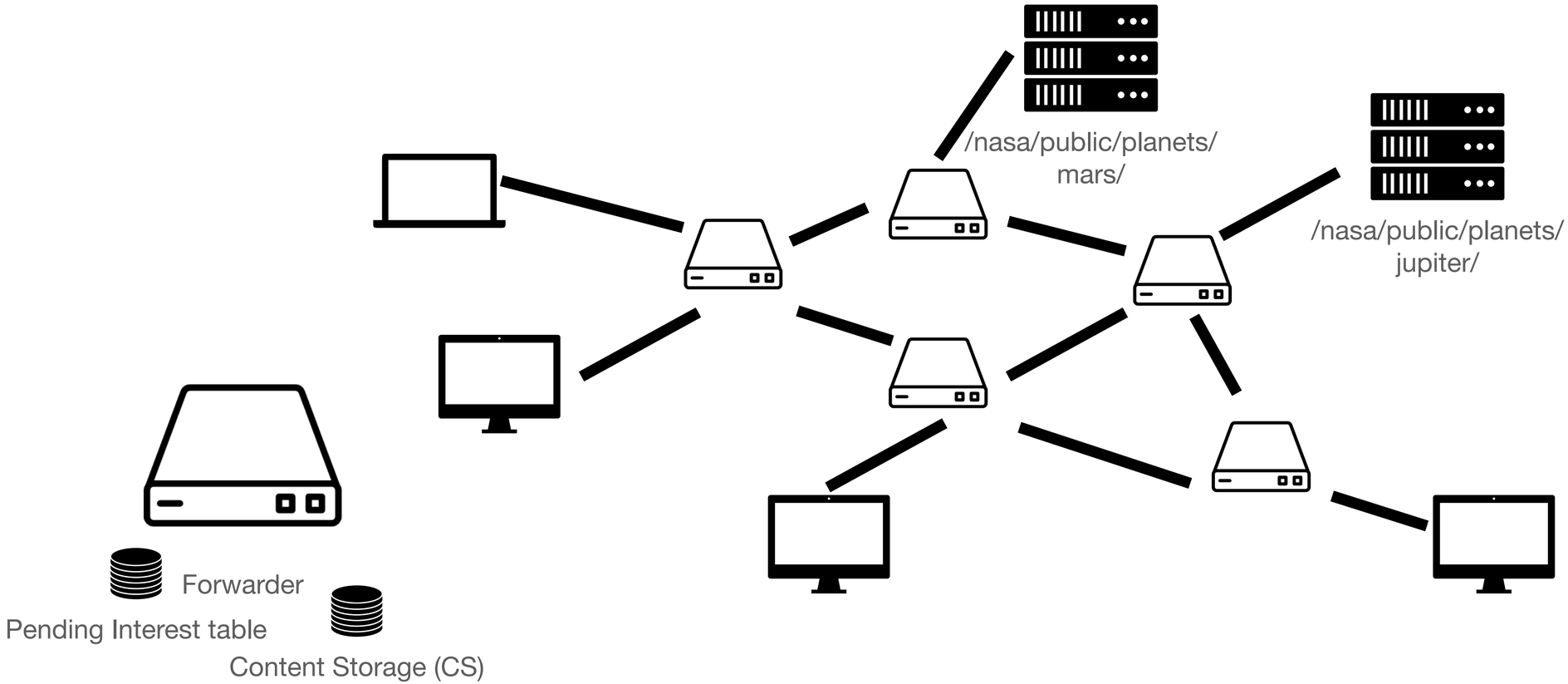

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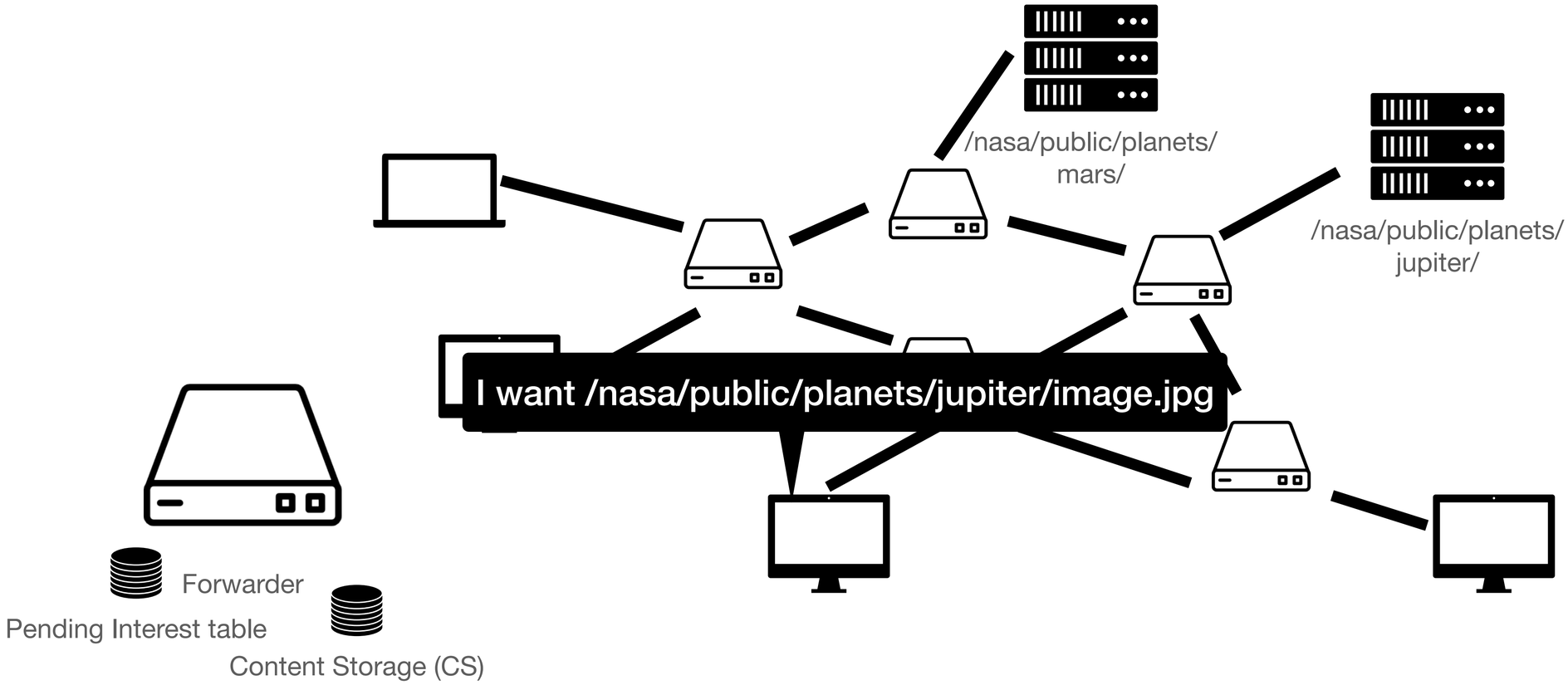

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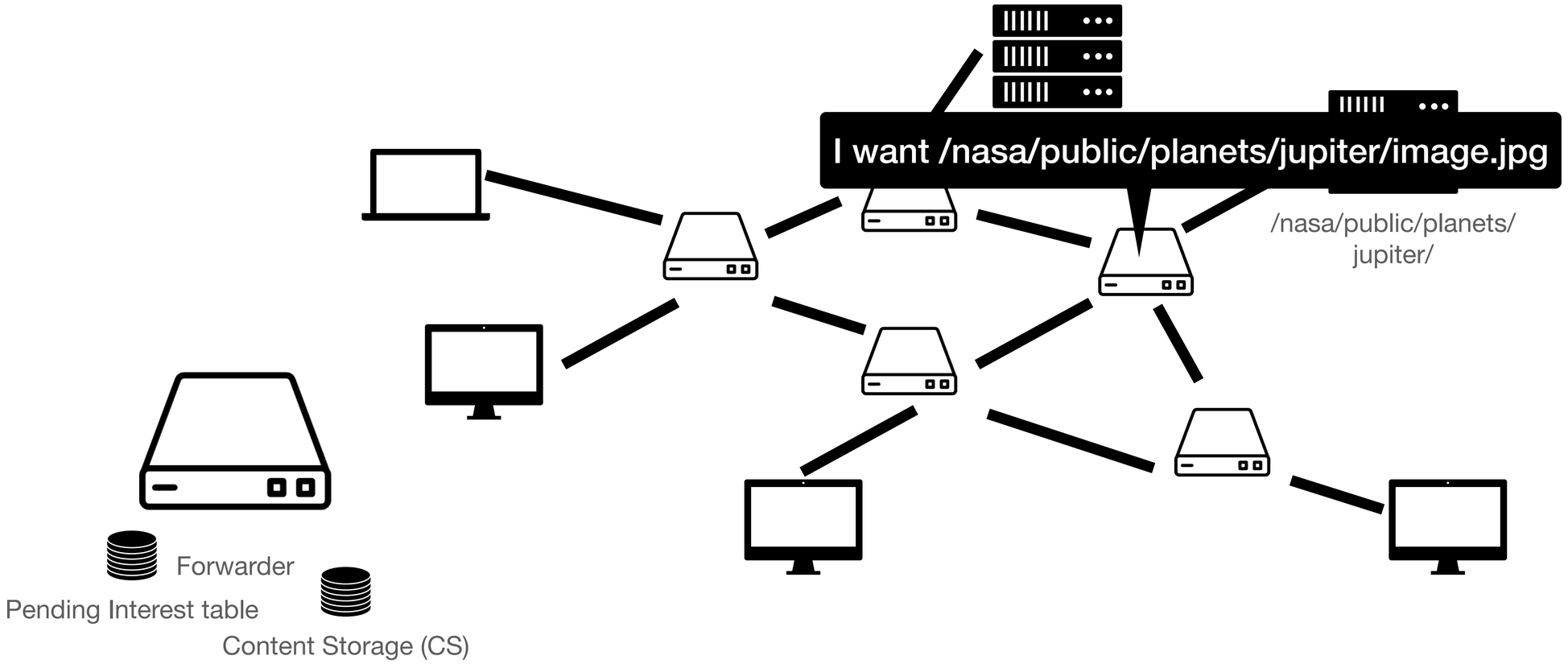

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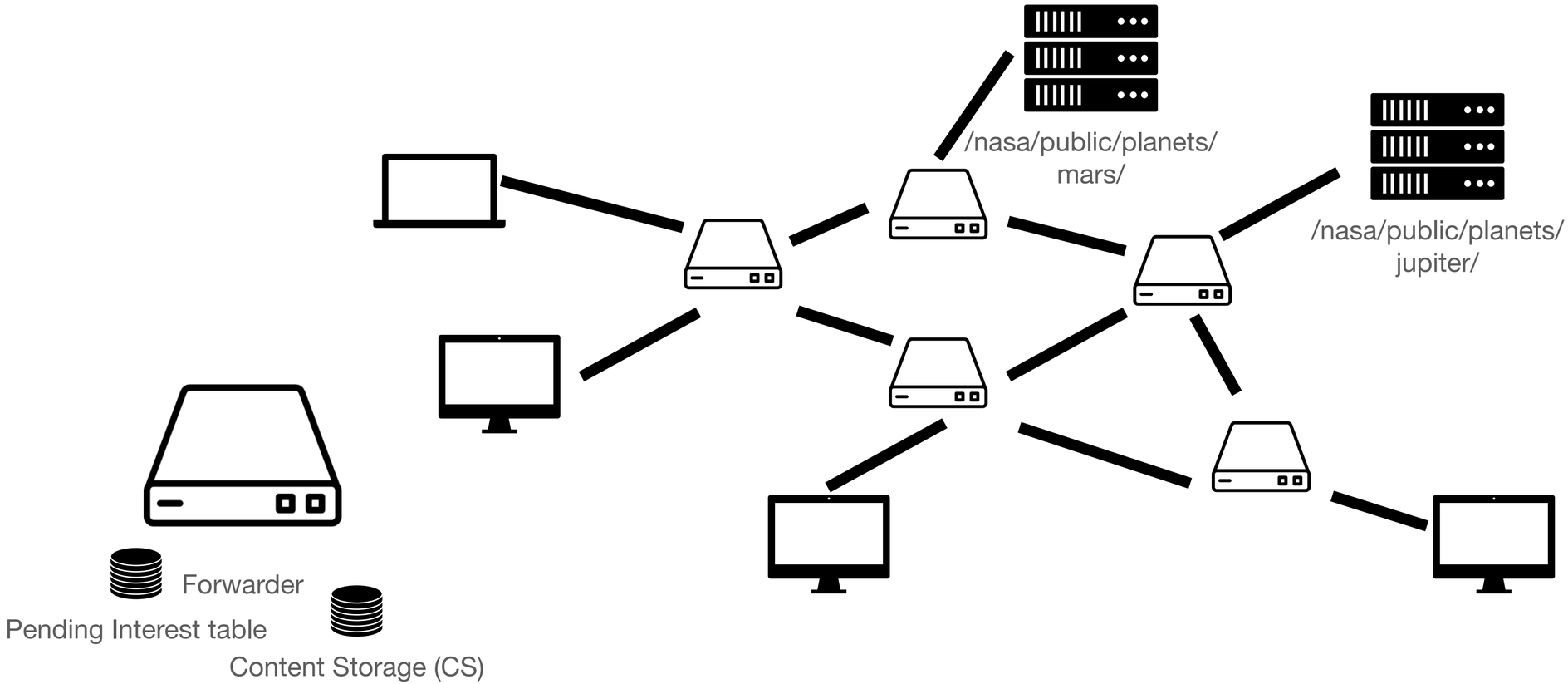

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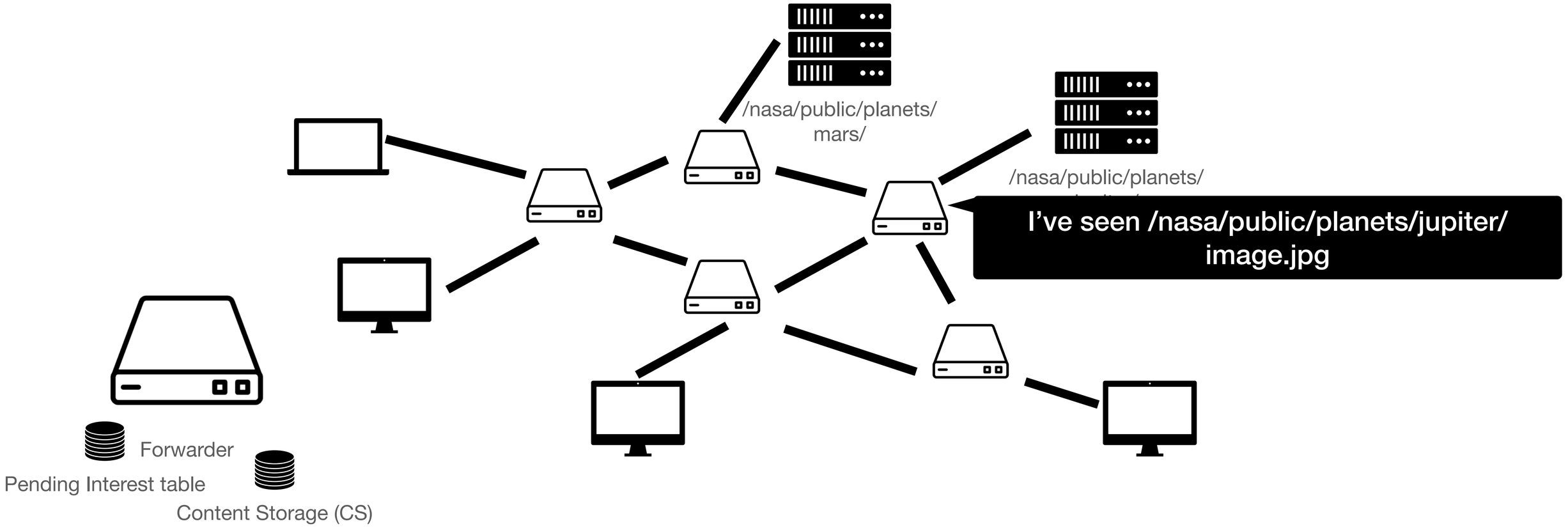

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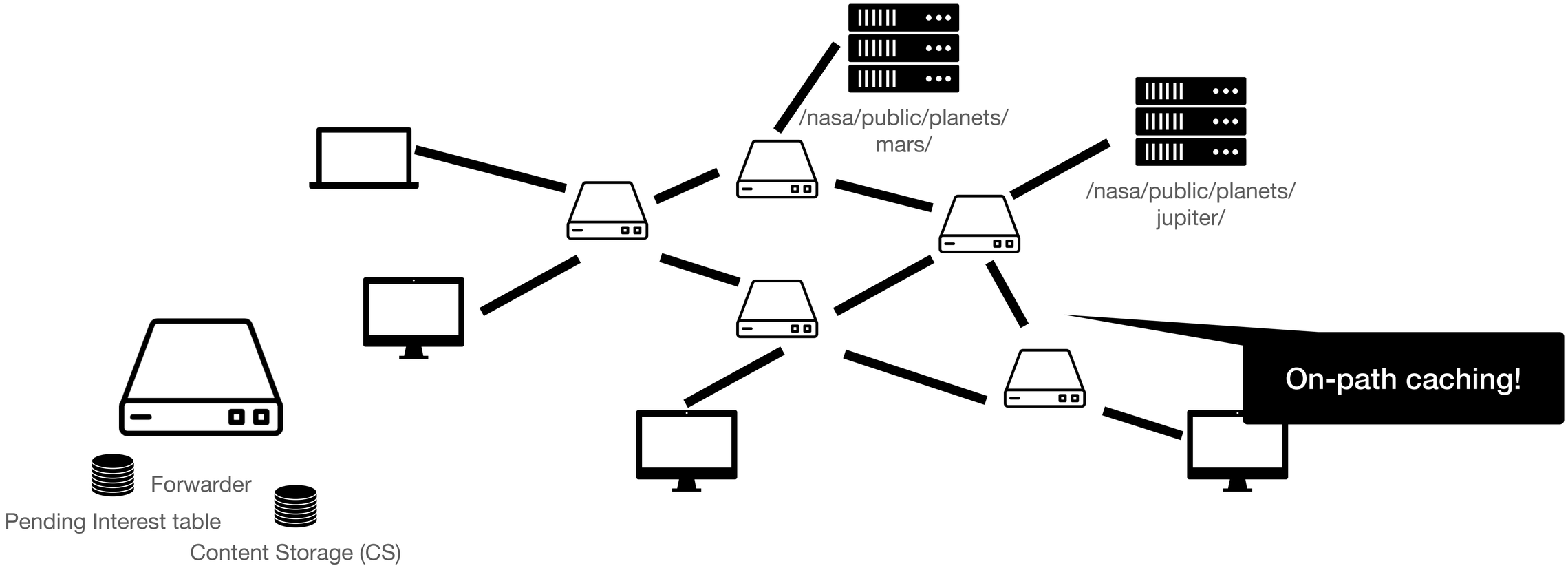

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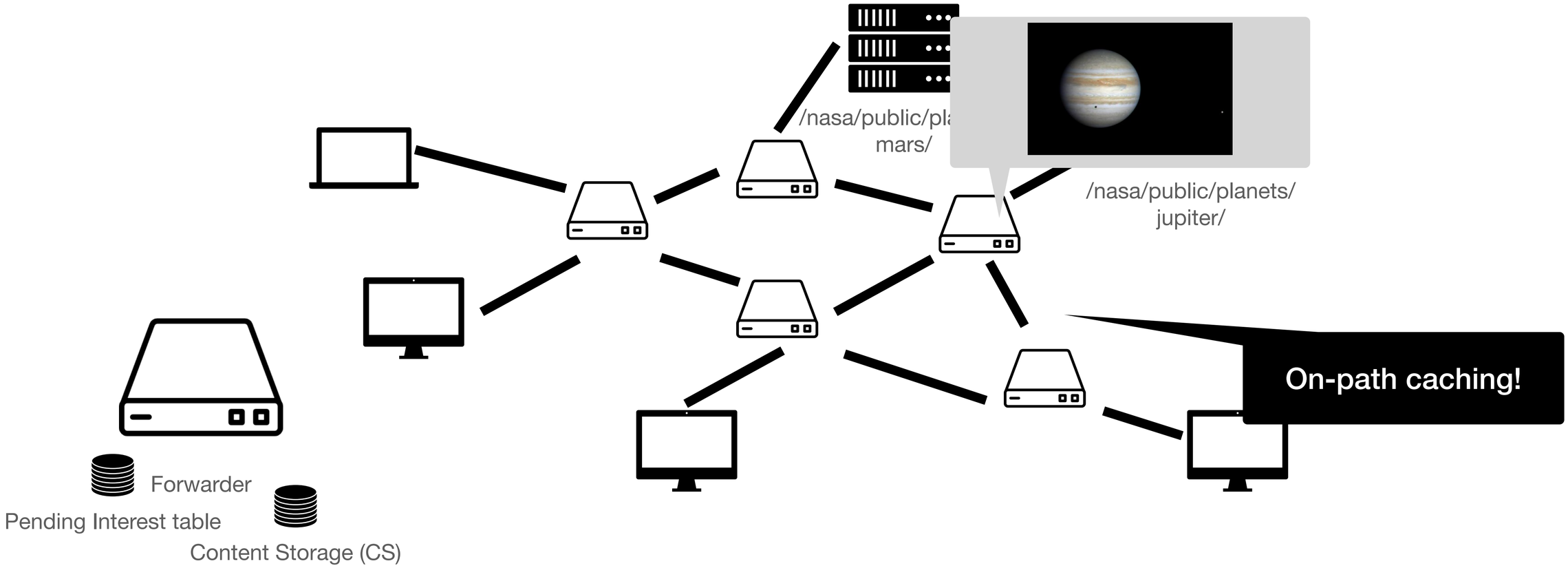

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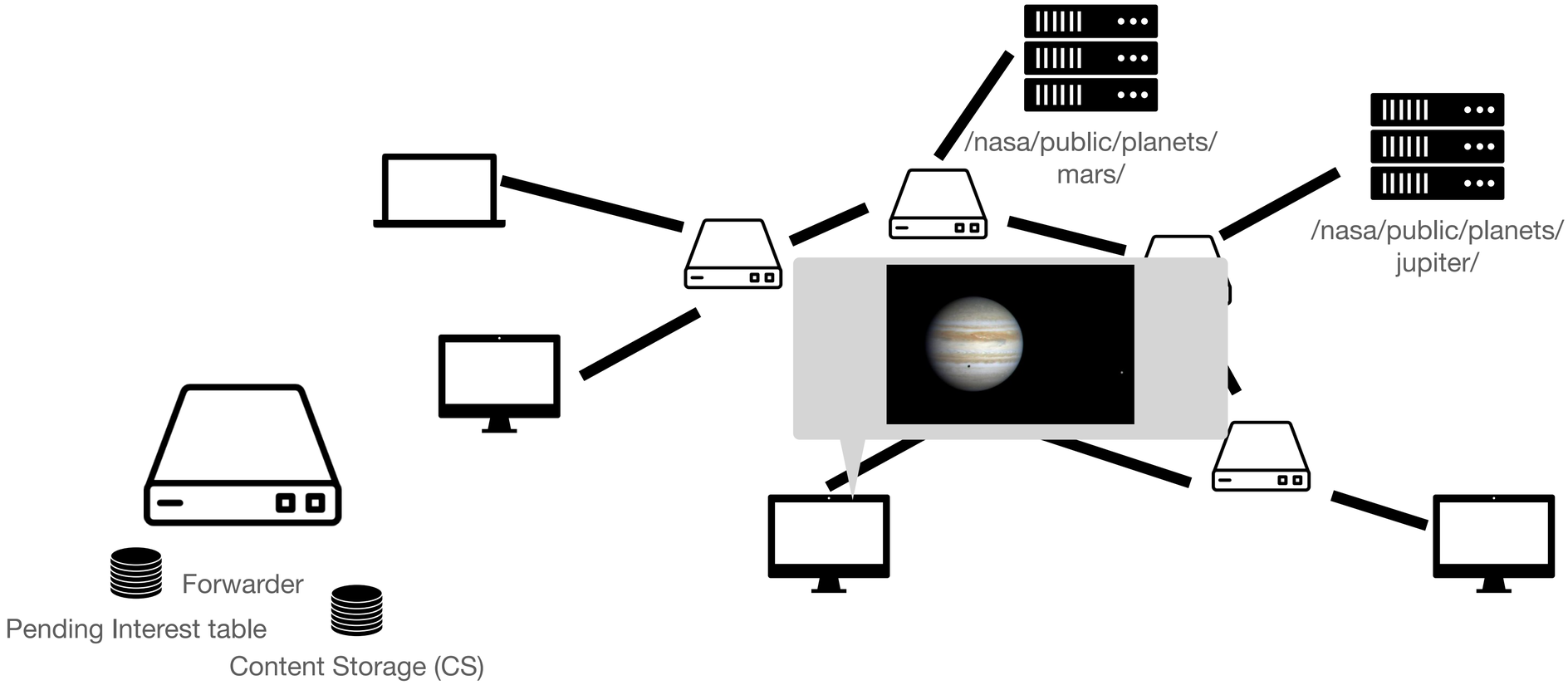

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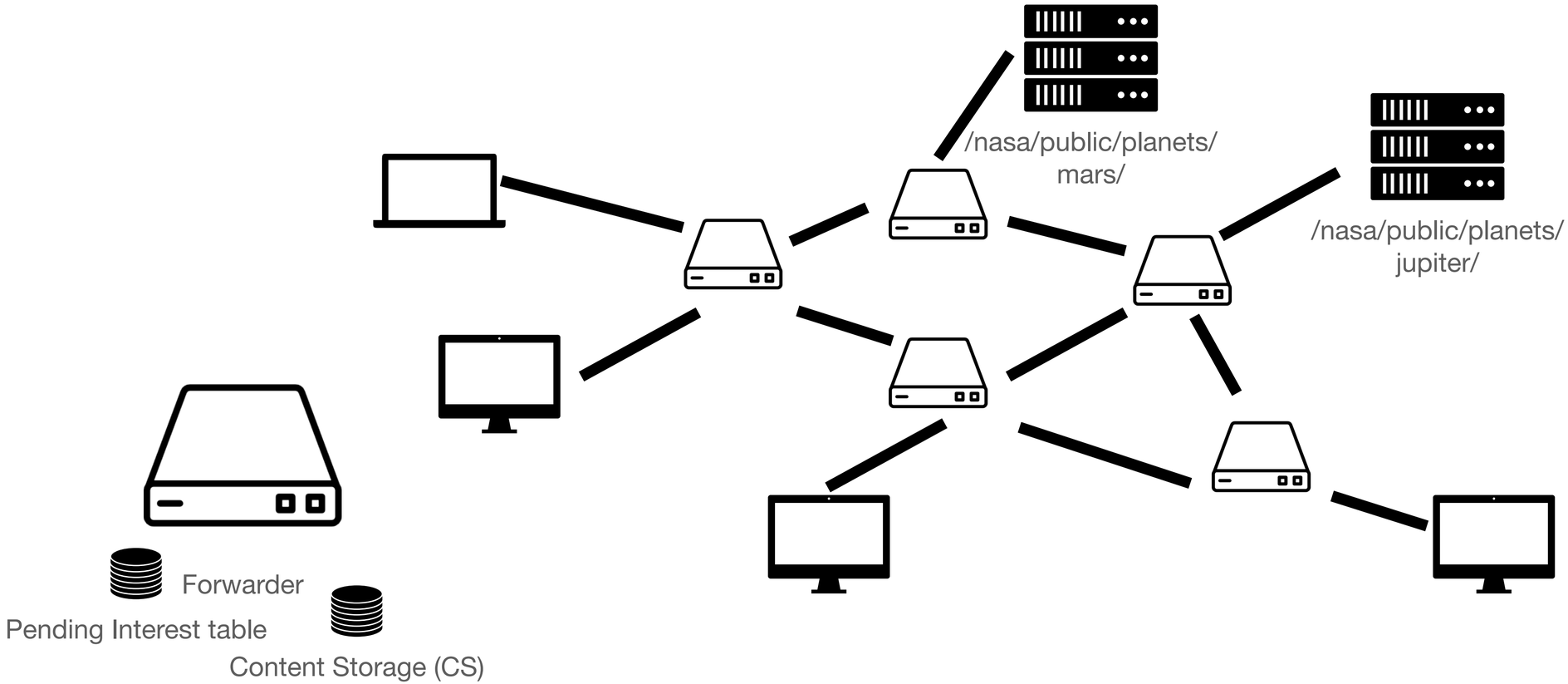

# Content Centric Networking (CCN) / Information Centric Networking (ICN)

Fundamentally different communication model:

- **Data-oriented** — Primary identifier is the name of the data/service
- **On-path caching** — Any node on forwarding path acts as a cache
- **Mobility as a first-class function**:
  - No point-to-point connection so no connection to break during handoff
- **No IP address provisioning and management**
- **No complex indirection management**

# Named-data Networking (NDN)

- Originates from the CCNx by Van Jacobson at PARC
- A CCN/ICN network protocol
- Can run over L2 directly, or IP using tcp/udp wrapper
- eco-system:
  - simulator available (NS-3 based)
  - miniNDN (mininet fork emulator)
  - C++ library

# Next step…

- Network management protocol & API
  - And management system using the protocol
- Distributed sensor system
  - leveraging named-function design
- Distributed file storage system
- Content Distribution Network
- Named functions
  - FaaS
- Name discovery

# Application: Distributed data storage

- Locality matters;
  - large files
  - latency sensitive
  - legal reasons
- File storage is already hierarchical -> may be straightforward to translate
- On-path caching; reducing latency and bandwidth usage for popular data

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- Named functions
  - FaaS, virtual network functions
- Name discovery