TOWARD A NAME-BASED, DATA-CENTRIC PLATFORM FOR SCIENTIFIC DATA

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A HUGE DATA EXAMPLE

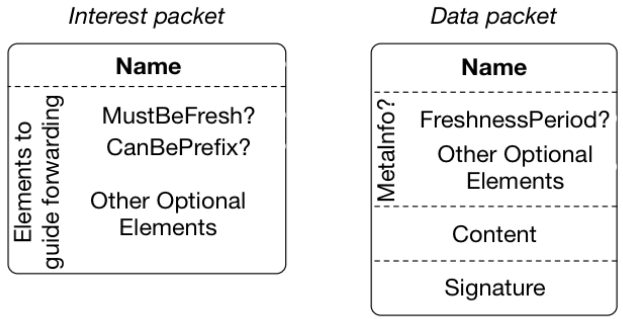
Consider a large study using data collected from thousands of participants

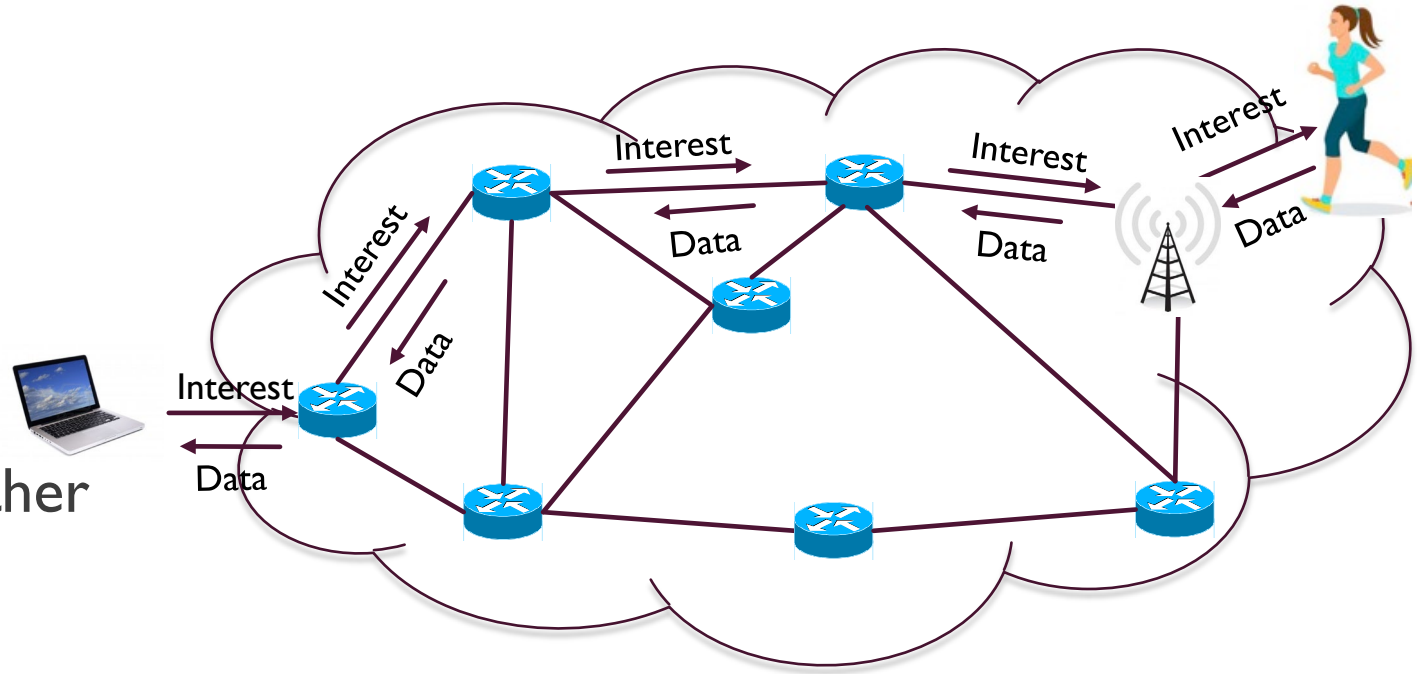
- How to collect, process, and distribute data in real-time?
- How to verify the integrity of computed results?
- How to ensure the data security and privacy of study participants?

Tokyo Marathon 2019 (right) and in 2020 (left). CREDIT: KYODO/REUTERS

NAMED DATA NETWORKING (NDN [1])

- **Name the data, not the container**
- Tell the network what you want (data name).
- Let the network find it for you.
- Verify data integrity and authenticity.
  - data signature
  - application-specific trust schema
- Intermediate nodes cache data for other users.

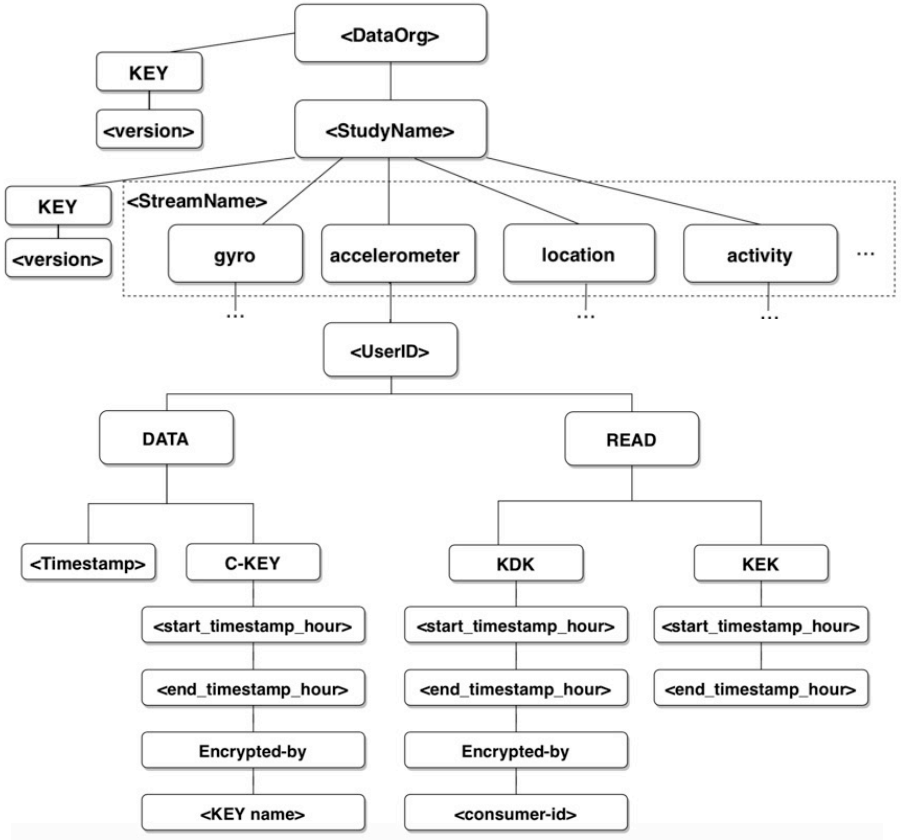




NDN packet forwarding

NAME-BASED DATA-CENTRIC PLATFORM

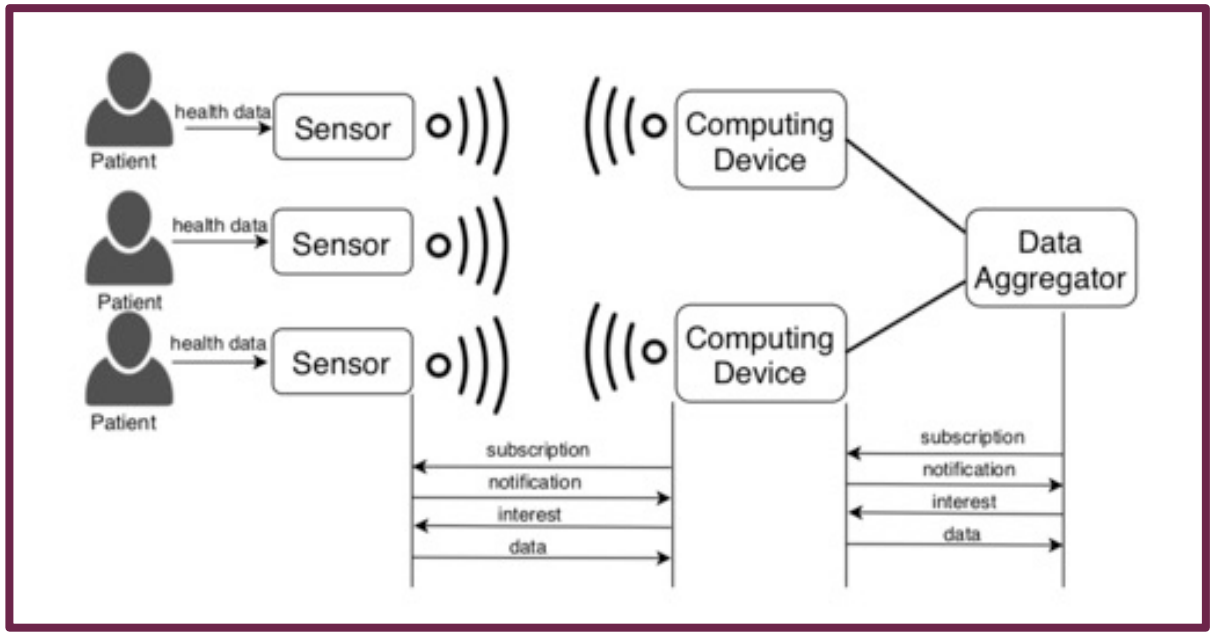
- Hierarchically named data
  - /<DataOrg>/<StudyName>/<StreamName>/<UserID>/DATA/<Timestamp>
    - Eg: /org/md2k/Tokyo19/gyro/alice/DATA/20000410053455
- Every piece of data contains a signature by the data producer.
- Individually named and secured data supports efficient data fetching, distributed processing, integrity, authenticity.



Sample Naming Scheme for a Study

DISTRIBUTED PROCESSING

- Data needs to be shared among sensors, computing devices, and end users.
- NDN Sync protocols [2] support multi-party data synchronization.
  - Use set reconciliation to sync the set of data names among group participants
- Pub-Sub API can be built on Sync [3].
  - A pub-sub system over NDN significantly simplifies the solution for distributed computing [4].
  - no centralized schedulers, DNS-based name translation, stateful load balancers, and heavy-weight transport protocols.



Distributed Computing of Health Data from Sensors through Pub-Sub over NDN

ENABLING DATA PROVENANCE

- How to verify data authenticity?
  - Data signing key indicates who produced the data.
  - NDN uses application-specific trust schemas [5] to automatically verify whether the owner of the key is authorized to produce the data.
- How to trace the series of computation and input data that led to a piece of data?
  - Use application naming scheme, data names, meta data

- What is new here?
  - Semantic naming enables systematic specification and automatic verification of the relationships between names (and the associated data).

Example: inferring activities from gyro and accelerator data

Input:
- gyro data: /org/md2k/mOral20/accelerator/alice/DATA/<timestamp>
- accelerator data: /org/md2k/mOral20/accelerator/alice/DATA/<timestamp>

Output:
- Inferred activity data: /org/md2k/mOral20/activity/alice/DATA/<starttime>-<endtime>/<compute-node>
- Meta data for activity data: /org/md2k/mOral20/activity-metadata/alice/DATA/<starttime>-<endtime>/<compute-node>
  - meta data contains (a) list of input data names, (b) inference algorithm, (c) parameters, (d) time of computation, …

NAME-BASED ACCESS CONTROL (NAC) [6]

- Define policies: who are given access to what dataset(s) with what restrictions.
  - Data users: /edu/memphis/lanwang
  - Datasets: /org/md2k/mOral20/gyro
  - Restrictions: data attributes and their ranges
- Enforce policies
  - Every piece of data is encrypted with a content key (C-KEY)
  - Encrypt and publish the C-KEY for only those users authorized to access the data

- How is this different from current access control (firewalls, SSL/TLS, …)?
  - End-to-end protection: data is encrypted both in transit and in storage.
  - Fine-grained: applied to data at every granularity, following the hierarchical name structure.

SUMMARY AND FUTURE WORK

- NAMING AND SECURING DATA DIRECTLY provides a foundation for
  - distributed processing
  - data provenance, confidentiality, automated fine-grained access control
- We are actively looking for collaborators to build a name-based data-centric software platform for large-scale scientific research over NDN.
  - Previous and ongoing NDN projects on supporting climate and HEP research [7, 8, 9]
  - More information about NDN software and testbed at www.named-data.net.

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