

# The NETWORK is a DATABASE!

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# Evolutions in Networking

- **Driven by applications**, services, regulations, ...
  - Telephony almost forever
  - IP success came from the end-users
- **Powered by technology**
  - Lower the entry cost
  - Enable new services and business models
  - Wireless, Optical, Hardware ...

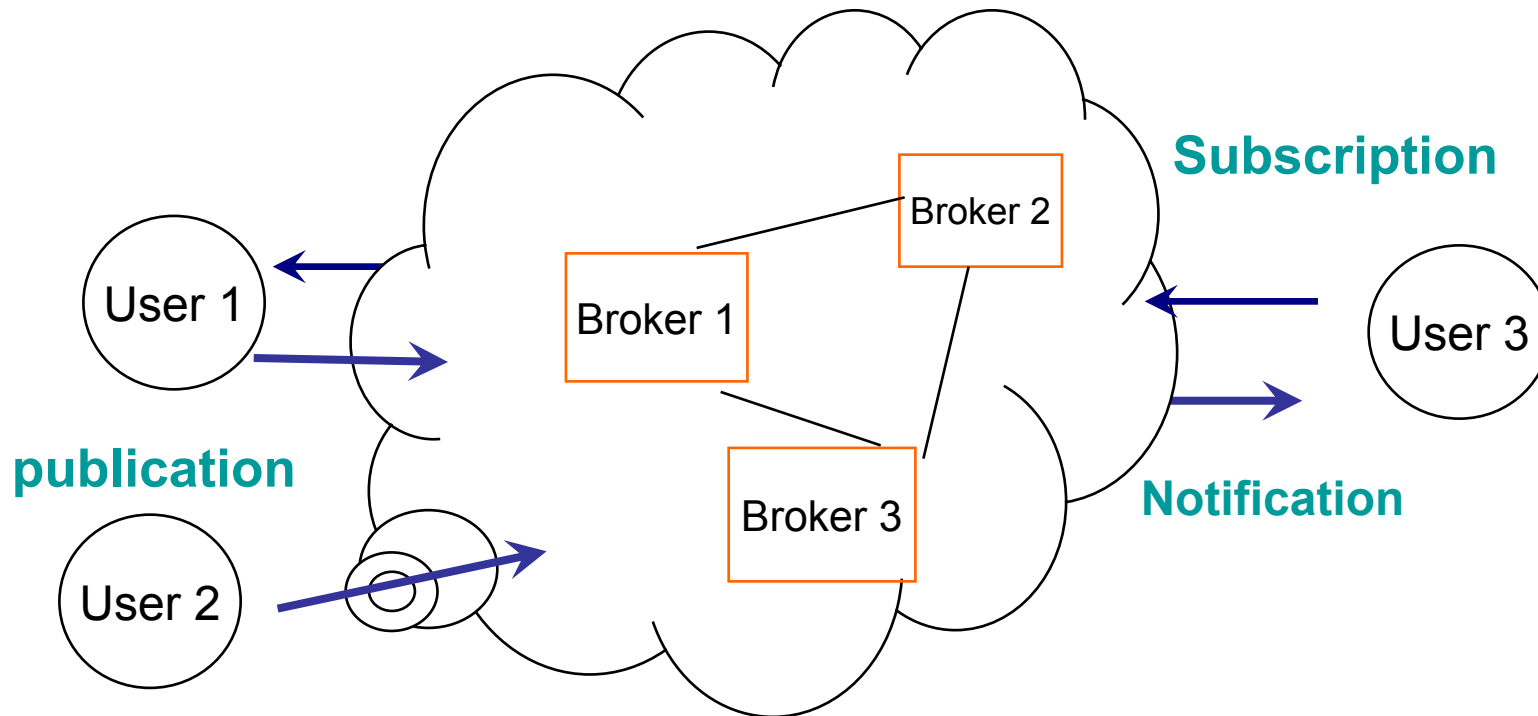
# Some observations on recent evolutions

- *CONTENT, who cares about Packets*
  - **Content** distribution is key
  - Huge amount of Data is transferred, but only a **limited set** of Data is of interest
  - Shared (“**Data to Many**”)
  - Traffic Engineering moving from **flows to services**
- *APPLICATION Oriented Architectures*
  - Emergence of **SOA** (Service Oriented Applications)
  - Fast growth of the Publish & Subscribe model (**PubSub**)
  - Companies are using Enterprise Service Buses (**ESBs**) and Federation of ESBs; **XML** based routers exists, IBM ODR, CISCO AON, ...

# Duality

- Transmission & Storage (content)
  - Servers/caches closer to the consumers when transmission is at cost
  - Network support
- Distribution models
  - Client-server
  - Push, Podcasting, ...
  - P2P
  - Publish-Subscribe (On-demand)

# Publish-Subscribe Systems



*Where will mediation  
take place?*

# Subscription Models

- Topic-based
  - Recipients are known a-priori
  - Limited expressiveness
- **Content-based**
  - Cannot determine recipients before publication
  - More flexible
  - Much more difficult to implement efficiently
- Type-based
  - Application of the other pub/sub systems on objects of the same type
  - Information-Type = main filtering attribute
- Location-aware (mobile env.)
  - Considers the proximity of publishers when sending a subscription.
  - Hard to monitor the mobility.

# Data/Service centric approach

- The transmission is **NO MORE** controlled by the **sender**, neither it is “addressed”
- Data is **selected upon request**, enabling a better control of information, filtering content to be received, enforcing robustness (SPAM, DDOS,...)
- Users require a service-oriented traffic management (**functional** approach) and no more a flow traffic management
- **DPI** (Deep Packet Inspection) will become available for interception, application classification, traffic management, exposing content in the network

# Content-based communication

- Senders simply publish messages
- Messages are not given explicit destination addresses
- Receivers declare their interests by means of selection **predicates (QUERY)**
- **MEDIATION done by Routers**
- The service consists of delivering to any receivers each message that **matches the selection predicates** declared by those receivers.
- Message content is structured as a set of **attribute/value pairs**, and a selection predicate is a logical disjunction of conjunctions of elementary constraints over the values of individual attributes

# Routing Mediation

- **Parse request** predicate to identify what service the request is requesting
- **Search locally (“domain”)** to determine if the service is available inside the domain
- If positive, and there exist policies for the request to be forwarded to this instance, **forward the request** to the appropriate node in the domain
- Otherwise, a provider of this service must be located outside of the domain. **Inter-domain service** discovery is requested

# Content-based routing building blocks

- Subscription, Dissemination, Revocation
- Content advertisement, notification, publication
- Routing, matching, Path filtering
- Content delivery, Forwarding
- Trust .....

# General scenario

- A node  $N$  stores a set of subscriptions

$$S = \{s_1, s_2, s_3, \dots, s_i\}$$

- $N$  receives an event  $e$
- $N$  searches for the subscriptions  $s$  corresponding to  $e$
- $N$  forwards  $e$  toward the interested subscribers

# Content-based networking

- **Revise** a large part of the architecture, including naming, addressing, routing, service discovery, access control, multicast, filtering, classification of packets, scalability, TE .....
- **Interoperability** of different service discovery protocols

## ▪ Select

(\***.http.\*** : **host** ~ \*mp3\*) or (\***.smtp.\*** :  
**content** ~ audio/\*) or (**base.\*** : **path** =  
kazaa)

# The Network is a Database