CS514: Intermediate Course in Computer Systems

Lecture 4: Sept. 10, 2003

"Introduction to Message Oriented Middleware (MOM)"

Overview of Lecture

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Introduction to Message Oriented Middleware (MOM)

- MOM versus OOM (Object Oriented Middleware)
- Goals of MOM
- Categories of MOM
  - Explicitly addressed versus publish/subscribe
  - One-to-many versus many-to-many
  - Guarantees
- Examples of MOMs
  - Email and SIP
  - Newsgroups
  - Message Bus (TIBCO)
  - Content routed (Gryphon)

MOM versus OOM

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- Message-oriented versus Object-oriented
- Seems to be a popular distinction to make
- Perhaps a strict definition:
  - OOM manufactures and passes around objects with method invocations, etc…
    - Corba, DCE, Java RMI, Microsoft DCOM
  - MOM passes around un-typed messages
    - IBM MQSeries, Lotus Notes, Sun JMS, TIBCO, even email and net news!
- But this definition probably doesn't get at the important distinction

MOM versus OOM

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Probably more important….

- MOMs are historically asynchronous, whereas OOMs are historically synchronous
  - Perhaps because OOMs evolved from OO languages
    - In the same way that RPC evolved from procedural languages
- Related to this, MOMs accommodates one-way message passing in addition to query/reply
  - i.e. a broader range of applications

Synch versus asynch

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- It is easier to make asynchronous perform like synchronous than vice versa
- Synch implies blocking, expectation of a reply
  - Which in turn implies a certain style of programming, one that requires an answer before progress can be made
  - Going asynch requires rethinking the whole flow of logic
- Asynch (non-blocking) is a more general programming style
  - If you make the reply fast, you can always choose to block…

MOM vs. OOM distinction is perhaps silly

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- Ultimately, OOM is a way to distribute an OO program, whereas MOM is a communications abstraction
  - Though both camps are trying to encompass the other
- The only thing the two terms have in common is “middleware”
- But what is “middleware”?
  - A very vague and ill-defined term

(We are only presenting these terms because industry throws them around)

Remember this picture? (Full-featured RPC)

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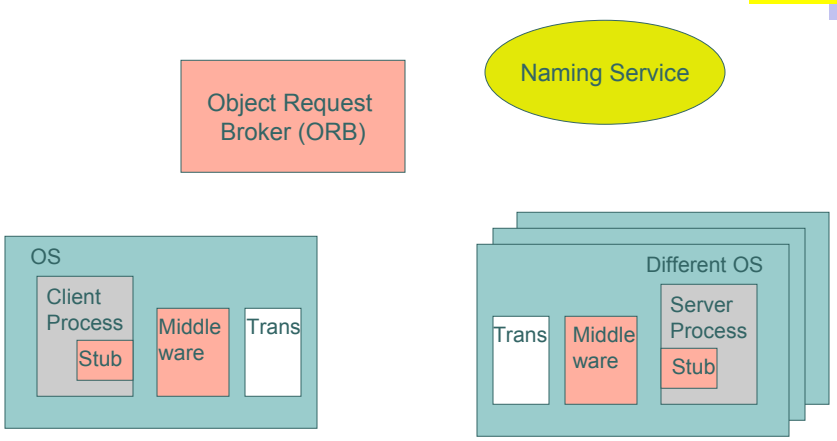

This stuff is ultimately optional

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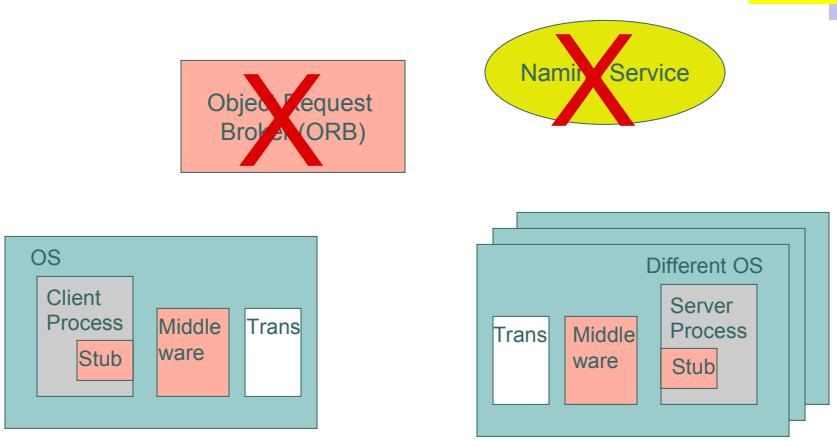

But not in a MOM system…

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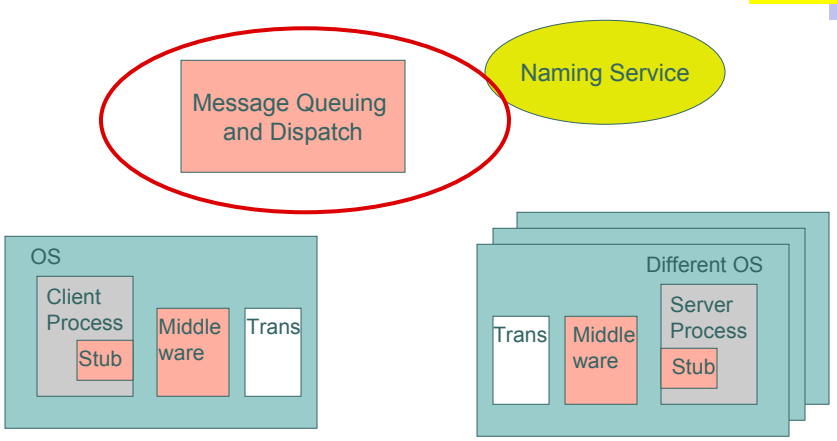

Various goals of MOMs

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- Of course integration of different system types
  - The one thing all “middleware” has in common!
- Delivery (persistence) and ordering guarantees
  - Eventually message will arrive in the right order
  - Prioritization
  - Causal ordering (i.e. knowing that A’s message 142 came after B’s message 217)
- Flexible addressing
  - “Function”-based as well as ID-based
  - Aids in system evolution
  - Point-to-point and one-to-many and many-to-many (event) communications models
- Increased system throughput

Example MOM Applications

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- Person-to-person messaging (email)
- Groupware applications
  - Planning, document sharing and editing, scheduling
- Database access
- Event notification (publish/subscribe)
- Workflows
- Many others

Various MOMs

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- Hub-and-Spoke
- Email
- Usenet (NNTP News Groups)
- SIP (Session Initiation Protocol)
- Message Bus (TIBCO)
- Content-based subscription (Gryphon)

Simple Hub-and-Spoke Model

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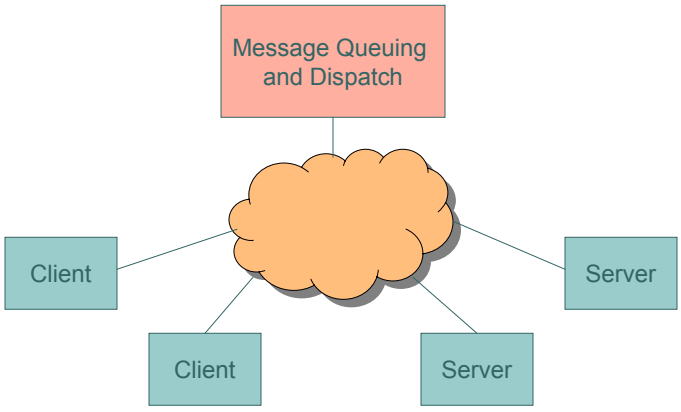

Some issues (client/server/dispatch configuration, user auth, user identification, flow control, message order), but obviously operation is fairly simple

Simple Hub-and-Spoke Model

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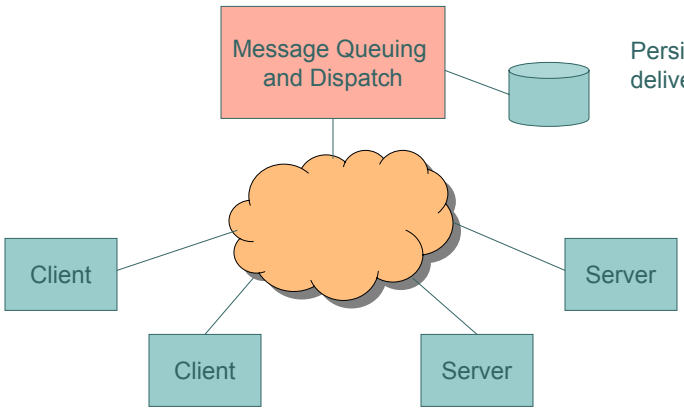

Persistent storage for delivery guarantees

Simple Hub-and-Spoke Model

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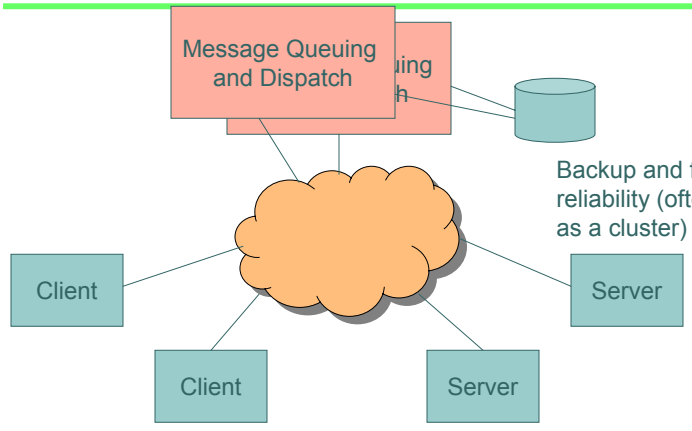

Obvious scaling limitations

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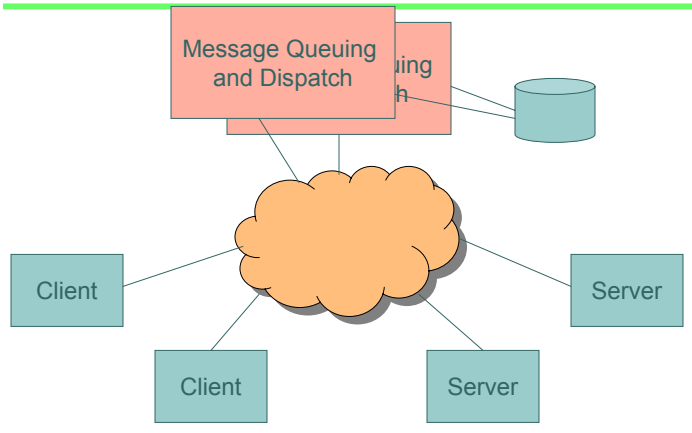

Though you can go pretty far with this model (hundreds of “spokes”)

Lots and lots of products

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- JMS (Java Messaging Service)
  - Sun ONE Middleware server
- Websphere MQ (MQSeries)
  - Has JMS interface
- MSMQ (Microsoft Messaging Queue)
- BEA Systems
- ObjectWeb (Open Source) JORAM (JMS)
- Fiorano
  - JMS interface
- Sonic Software (Sonic MQ)
- etc….

Network of Hub-and-Spoke

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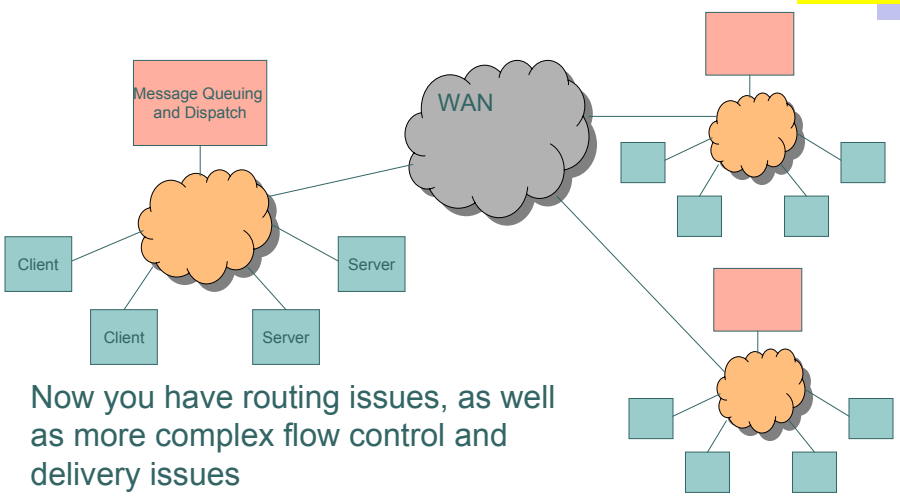

Now you have routing issues, as well as more complex flow control and delivery issues

Typical routing is hierarchical and static

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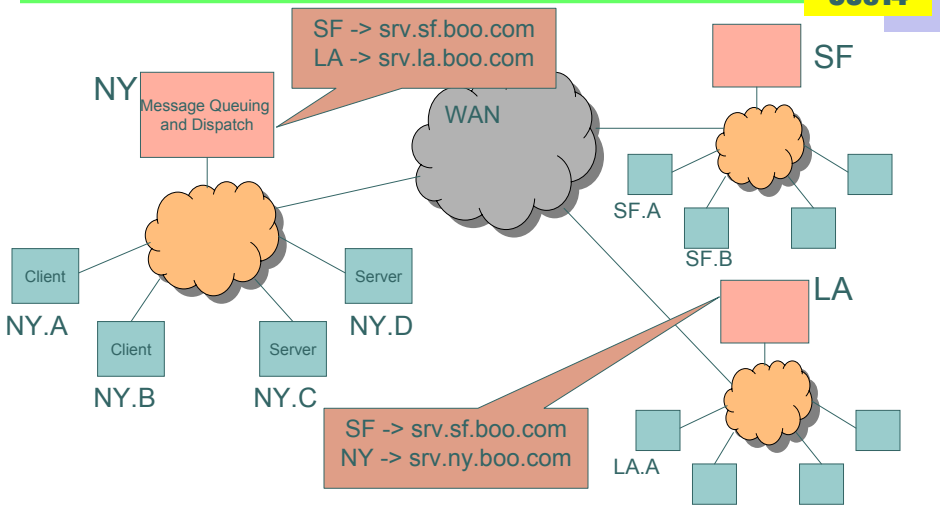

Email

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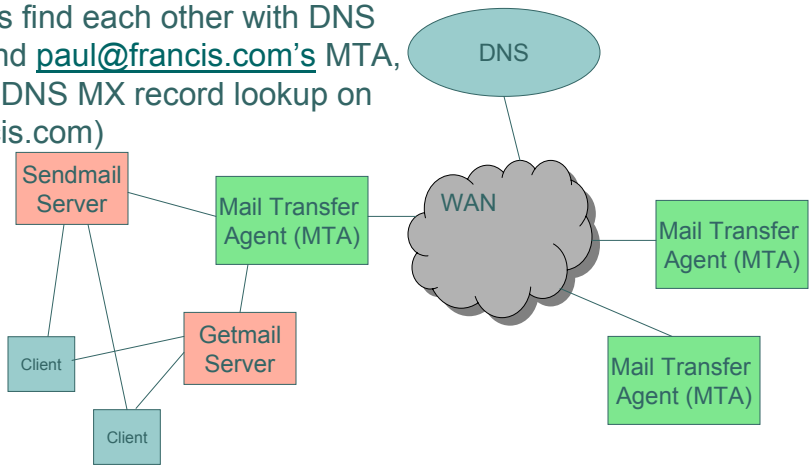
MTAs find each other with DNS (to find paul@francis.com's MTA, do a DNS MX record lookup on francis.com)



Email

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- List of MTAs prevents routing loops
- No guaranteed delivery
- Limited causal message ordering
- Addressing
  - Point-to-point (explicit, with address list aliasing)
  - One-to-many or many-to-many
    - "Topic" or "Channel" publish/subscribe semantics through various add-on list management tools
    - But delivery mechanism is a list of destination addresses (possibly with local exploders)

Usenet (News Groups, NNTP)

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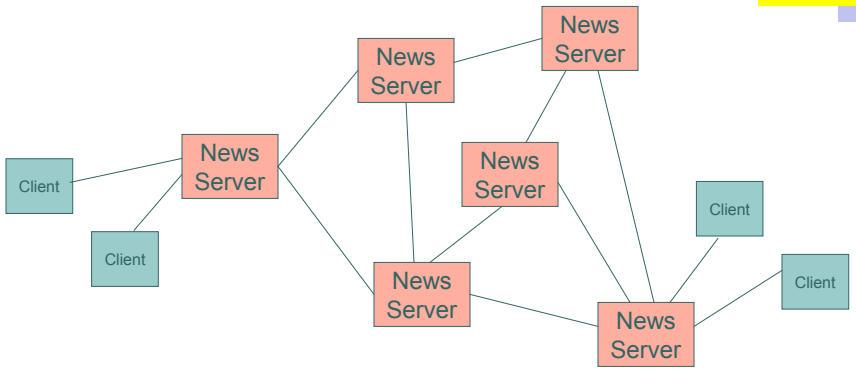

Messages are flooded to all news servers (with duplicate suppression)

Usenet (News Groups, NNTP)

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- Publish/Subscribe semantics (rec.arts.origami)
  - Many-to-many only
  - Broadcasts all topics/channels
- No delivery guarantees (by a long stretch!)
- Some causal ordering
- Note primary motivation for design was to save disk space on clients!
  - Creation of groups used to be tightly controlled
  - I think Moore's law has bypassed Usenet!

SIP (Session Initiation Protocol)

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- Originally a Voice/Video over IP signaling protocol
  - Joe wants to talk to Sue over the Internet, needs to:
    - Signal that fact (ring her phone)
    - Negotiate what voice coding format to use, etc.
- Expanded to include presence and messaging (called "SIMPLE")
  - Microsoft is behind this

SIP Architecture

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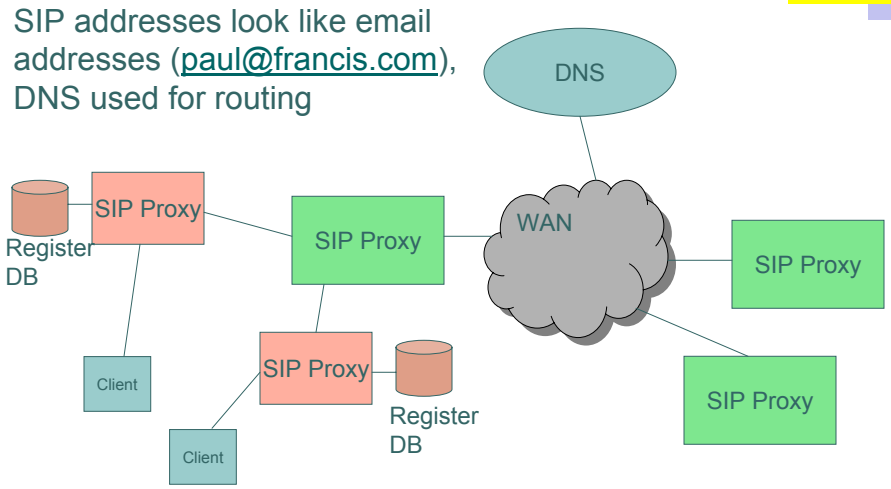
SIP addresses look like email addresses (paul@francis.com), DNS used for routing



SIP versus email

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Email is async with storage in the middle	SIP is (mainly) sync with a stateless middle (delivery semantics E2E)
Email users contact server when they want to get/send messages.	SIP users register their location(s) to the “proxy”, are continuously reachable by the proxy
Email has MIME encoding	SIP has MIME encoding
Email has user@dns-domain addresses	SIP has user@dns-domain addresses

I think SIP is important

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- It hasn't (quite) reached critical mass
- It hasn't seeped into the consciousness of the middleware community
- But it is powerful in fundamental ways (like email and http are)
  - HTTP: Client contact any (up) server instantly
  - Email: Peer contacts any peer with delay
  - SIP: Peer contacts any (up) peer instantly

Message Bus (TIBCO)

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- Most famous for publish/subscribe event service
  - But also has point-to-point
  - Usenet is publish/subscribe, but not event
  - Topic based subscriptions, but somewhat more general than Usenet
    - Can do wild-carding at each name level
    - People.*.Schwarzenegger matches both people.actors.Schwarzenegger and people.politicians.Schwarzenegger

Images borrowed from Chris Ré's CS614 talk

TIBCO Architecture

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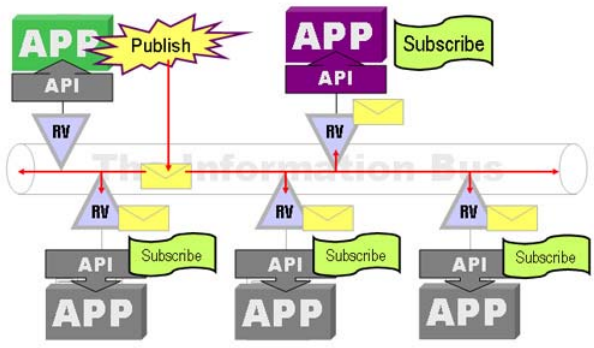

TIBCO Architecture

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- Makes heavy use of LAN broadcast
- Every node listens to all messages
  - But only passes up those to which it has subscribed
  - Scaling limitation, but ok for many cases
- Runs “reliable” protocol over UDP
  - Sequence number per publisher per topic
  - Periodically broadcast update message with last transmitted sequence number
  - If subscriber hasn’t seen it, requests retransmission
  - But eventually publisher deletes message

Subject-based addressing

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- Key concept is that publishers and subscribers don't need to know about each other explicitly
  - Makes it easy to add and remove boxes and applications
- Publish: destination address is conceptually "everyone interested in this topic"

Subject-based addressing flexibility

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- Use to discover services or specific nodes:
  - Printer p1 in systems lab subscribes to following:
    - printers.syslab.p1
  - To find printer p1, publish:
    - printers.*.p1
  - To find any printer in syslab, publish:
    - printers.syslab.*
  - Either way, p1 will receive message and reply directly (point-to-point)
    - Message contains a "call-back" command

Subject-based Addressing abstraction not perfect

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- For “guaranteed” message delivery, publisher requires subscriber acks
  - Must know all subscribers explicitly
  - Will periodically republish message until all acks received
  - Gives up eventually
    - Network partitions will result in failed delivery, though at least publisher will know it

WAN architecture: required because no WAN multicast

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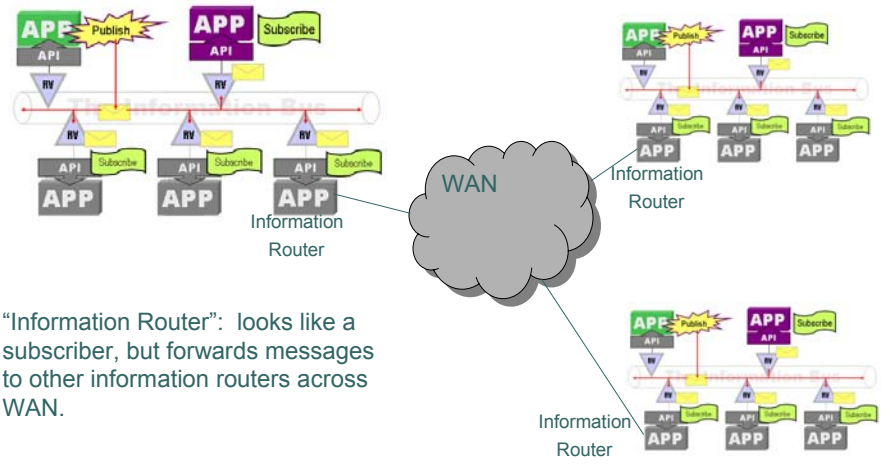

“Information Router”: looks like a subscriber, but forwards messages to other information routers across WAN.

TIBCO WAN Issues

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- To avoid broadcast of all messages to all sites:
  - Information router must know local subscriptions, tell other information routers
  - No longer “silent subscribe”
    - (perhaps never was?)
- Reliability/guarantees harder
  - Information router crash causes partition
- Ultimately, the “Information Bus” is not as transparent and simple as it appears
  - And later we’ll find that reliable multicast is hard to scale

Content-based subscription

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- Don’t define topics, rather subscribe based on contents of message
  - “all messages with Schwarzenegger in body”
- Or values of predicates
  - Stock ticks with ATT > 30
- Like a relational database turned on its head
  - Match entry against many queries!

Approach

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- Broker collects subscriptions
- Broker receives published messages with attributes and values, and matches them against subscriptions
- Hard part:
  - Doing this scalably
- Basic idea:
  - Build a tree data structure from subscriptions, walk tree with published messages

Simple Example:

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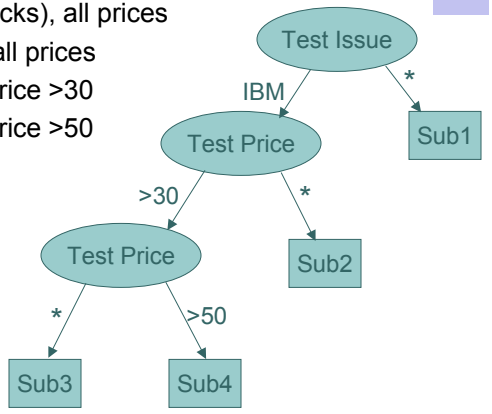
- Sub1: All issues (stocks), all prices
- Sub2: Issue = IBM, all prices
- Sub3: Issue = IBM, price >30
- Sub4: Issue = IBM, price >50



See IBM Gryphon project for more details