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DAFs and Management in RINA

PSOC Workshop

Dublin, Ireland

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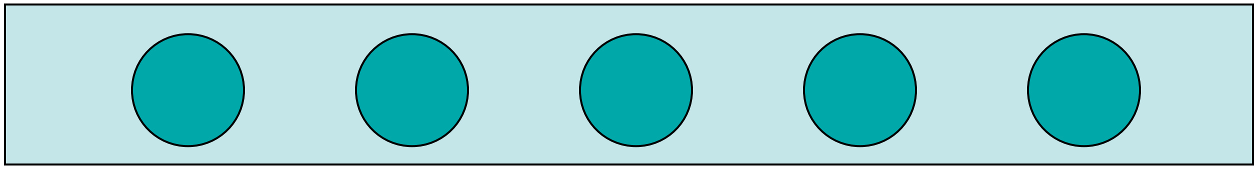
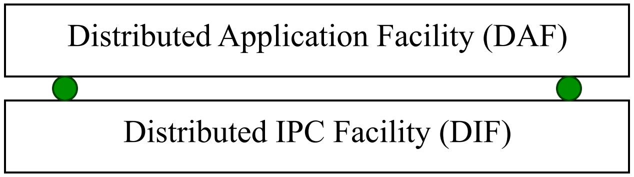
A DAF consists of two or more DAPs

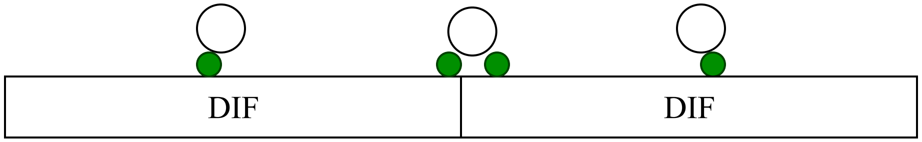


- Notice that everything is a DAF. An Application that does not use IPC has no output and hence does nothing.
- A DAF in which all DAPs are of the same type is *homogeneous*.
- A DAF with DAPs of different types is *heterogeneous*.
- A new Application Process joining a DAF must enroll.
  - It works just like DIFs, actually DIFs work just like DAFs.
- The DAF may assign the member DAPs a synonym with scope limited to the DAF and structured to facilitate its use within the DAF.

DAFs Operate Over A DIF

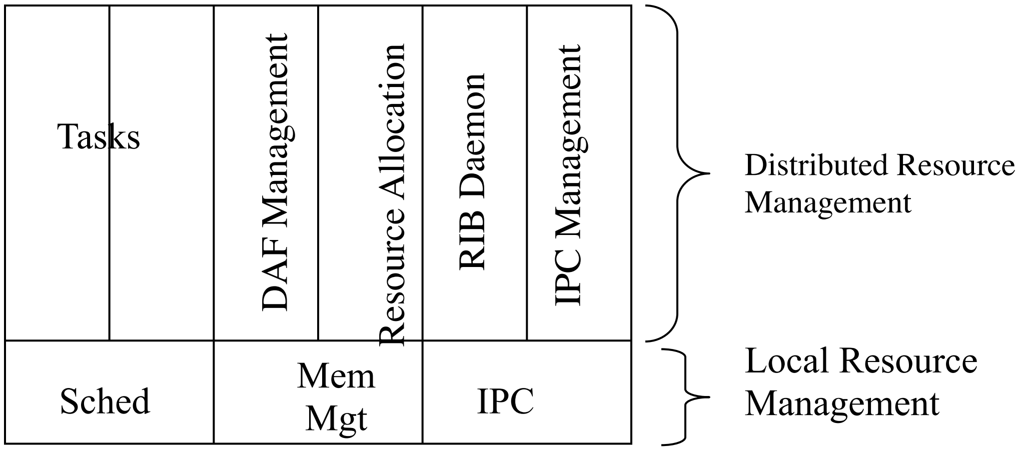

Distributed Application Facility (DAF)
Distributed IPC Facility (DIF)

Can a DAF span more than One DIF?



- There seems to be no architectural reason why not.
- This requires at least one DAP relaying which could allow information to leak between domains.
- Rules can be made but are hard to enforce, but these are not as strong as it being enforced by the structure.

A DAP Consists of



Tasks

DAF Management

Resource Allocation

RIB Daemon

IPC Management

Sched

Mem Mgt

IPC

Distributed Resource Management

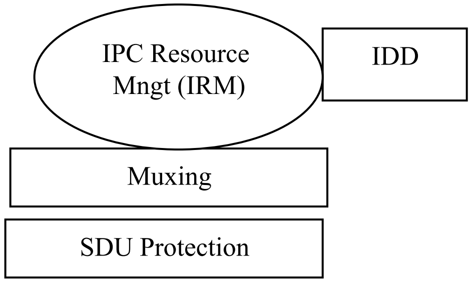
Local Resource Management

- This requires considerably more exploration.
- Conjecture: In general the Tasks do not use IPC, but the RIB Daemon makes the information available that the tasks need.
  - IOW, the function of a distributed application is reduced to a local programming problem.
  - Not only is there only one application protocol but there is only one user of that application protocol?

DAP Infrastructure

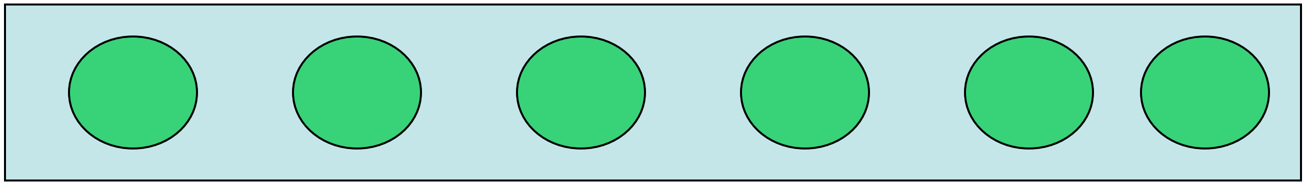
- **DAF Management** is the local task involved in the management of the DAF as a whole. It can range in complexity from a simple agent to a full participant in the management. (more on this later)
- **Task Scheduling** - is the local task that coordinates with its peers the work of the DAF. (In a DIF, this is generally relates to routing and QoS.)
- **RIB Daemon** - is the local task that ensures replicated information in the RIB is updated as required and services requests for information from the Tasks of the DAF. (In a DIF, this is a generalization of combining routing update and event management.)
- **IPC Management** - IPC Management manages the DAP's use of the underlying DIF to communicate with its members. (There is much more to say about this)

IPC Management



- In the IPC Model, there was a function that was used to choose which DIF to use. This is it.
- IPC Management is the part of a DAP that manages the use of the supporting DIF.
  - SDU Protection and Multiplexing are the same as in DIFs.
  - The IPC Resource Manager (IRM) does the actual management
  - The Inter-DIF-Directory (IDD) is used to find applications that may be on DIFs that this DAP does not have direct access to.

Naming Considerations for DAFs



- The members of a DAF cooperate to perform a set of functions. Hence, they may have a shared schema that describes the information they use.
  - And policies governing replication, ACID, authoritative value, etc.
- This schema may or may not be made visible to the users of the DAF.
- One of the roles of the RIB Daemon is to maintain the mapping between this schema and how to access the information, i.e. where in the DAF this information resides.
  - Hence, synonyms may be assigned to facilitate this, e.g. DHTs, LC
- The Tasks of the DAF use this schema to access the information required to perform the functions of the DAF.
  - The schema made visible by the tasks may be different than the schema used within the RIB.

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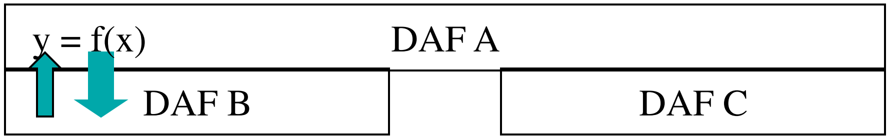
Very Interesting . . .

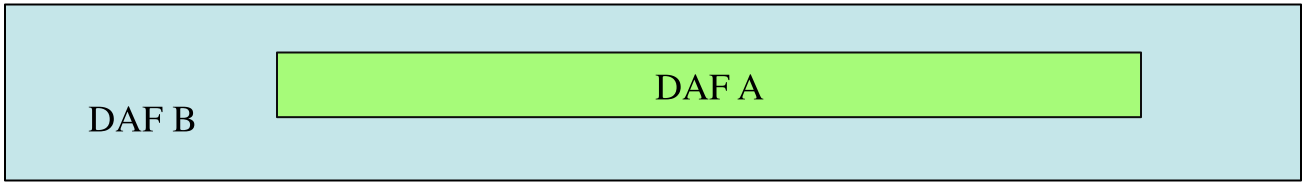
- How much in common DAFs and DIFs are:
  - SDU Protection
  - Multiplexing
  - RIB Daemon
  - Enrollment
  - Addresses (Synonyms)
- Ignoring differences of policies, not much is unique to DIFs:
  - Flow Allocator
  - Delimiting
  - Error and Flow Control
  - (Relaying)
- Like I said, Very Interesting. . .

Can DAFs Use DAFs?



- Yes, of course. But there are two forms it can take.
  - Invoke
  - RPC
- In general, a DAF provides some function (or set of functions) and will provide the result of that function to the member of the DAF that invoked.
  - Assume DAF B provides f(x) and it is invoked by a member of DAF A
  - B returns the result to the member that made the request. The fact that it was a distributed computation is not visible to A, is termed *asymmetric*.
  - A rare form of DAF, where performing f(x) by one user may result in $f^{-1}(x)$ being performed elsewhere, is termed *symmetric*, e.g. a DIF.

DAFs Can Include DAFs

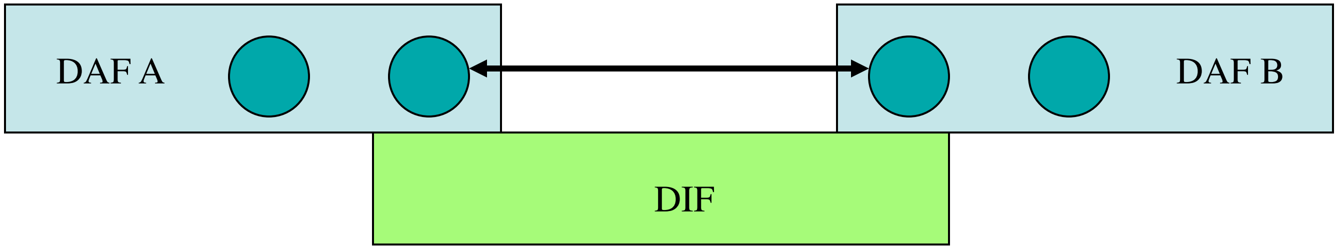


DAF A

DAF B

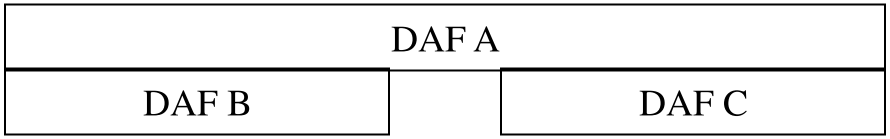
- A DAF can include another DAF in a symbiotic relation, where the encompassing DAF provides all of the infrastructure services,
- Distinct DAF where the encompassed DAF provides its own infrastructure.

Can DAFs Use DAFs? (cont)

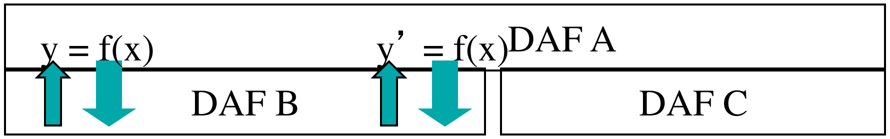


- The Remote Procedure Call form:
  - A DAP, **a**, in DAF **A** opens a connection to a DAP, **b**, in DAF **B**, (which includes authenticating) and sends f(x).
    - **a** and **b** must be in two DAFs at the same time.
  - This could constitute any number of security problems.
    - Information available to **a** as a member of **A** may not be shared with **B**. Major assumptions have to be made about the veracity of **a**.
    - The previous method provided more structural isolation.
  - Note that f(x) is not enrollment. For this sort of service, there are a number of possibilities: distinct DAN, distinct AE in a DAP, or distinct DAPs to provide the function and isolate it from the rest of the DAF.

Can DAFs Use DAFs? (cont)



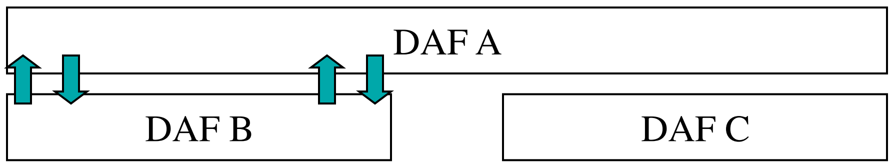
- Do all members of A have access to the same supporting DAFs?
  - For a homogeneous DAF, yes. For a heterogeneous DAF, perhaps not.



where y may not equal y'

  - If one member of A invokes f(x), the result might not be the same if another member of A invokes f(x)

Can DAFs Use DAFs? (still cont)



- A DIF is a special case such that when f(x) is invoked, $f^{-1}(x)$ is invoked elsewhere, i.e. symmetric.
  - Are there other forms of symmetric DAFs where f(x) causes action at a distance where f, f^{-1}, or even g are invoked?
    - Yes, email, various "messaging" schemes or some delay tolerant networks
- Ultimately, it would seem that a DAF has at least one supporting DIF for sharing information among its members.
  - Is there an example that proves this statement wrong?

Conjectures

- Peer to Peer [sic] systems are asymmetric homogeneous DAFs, where the RIB Daemon maintains a schema to locate information at one or more members of the DAF and then transfer the information to the requesting DAF member.
- Email is a symmetric DAF that stores a message with the user of another member. The message may be retrieved at some point by another member of this DAF or by another DAF.
  - Mail could be a DIF if there is an upper bound on how long a message will be held before pick up.
- Content-centric networking is simply a distributed database DAF.
- Others?

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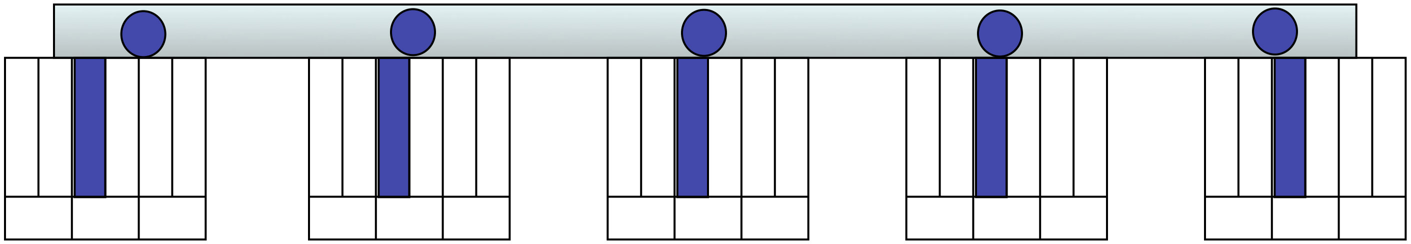
Management DAFs

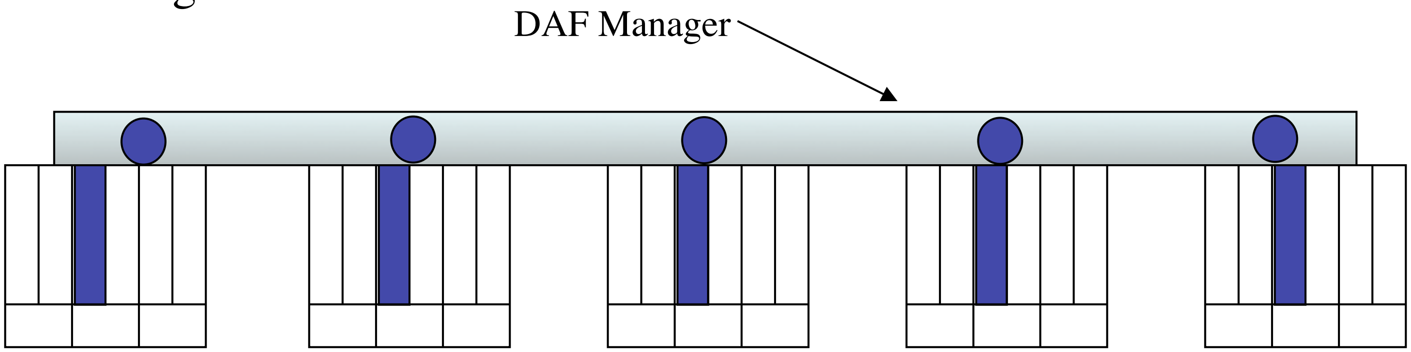


An Important Class of DAFs:
DAF Management Systems

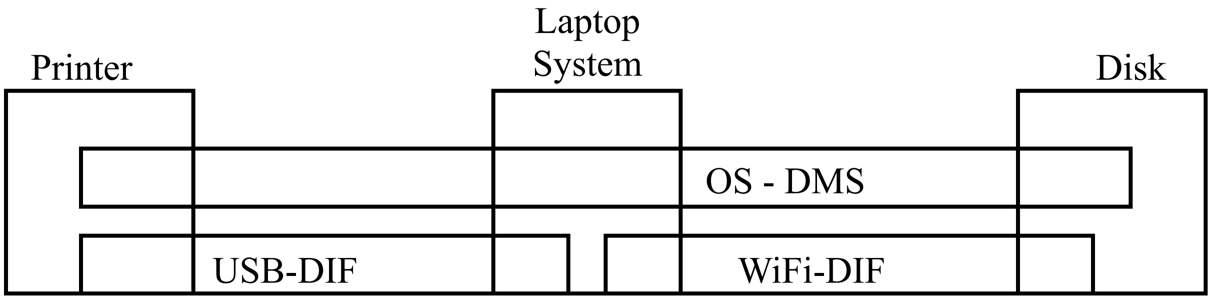
- There are four major kinds of distributed management systems (DMS):
  - Operating System
  - Distributed Applications
  - Network Management
  - Name Space Management
- There were the beginnings of progress in this area in the late 80s.
- However, thanks to the SNMP debacle of the early 90s,
  - The IETF were played for suckers and took the bait
- It pretty much reverted to the primitive state of 70s with ad hoc, largely, proprietary solutions and kludges,
- Effectively aimed at keeping account control and using management as a barrier to entry.

DAF Management Systems

- There is a commonality to their structure and
- A range in their complexity from distributed to centralized
- Each DAF/DIF has a DAF Management Task. These constitute data collection and autonomic functions, what IEEE calls layer management.
- The DAF Manager can be considered the nervous system of a DAF.
  - A DAF Manager might manage more than one DAF or
  - In a degenerate case, the DAF Management Tasks might constitute the DAF Manager.

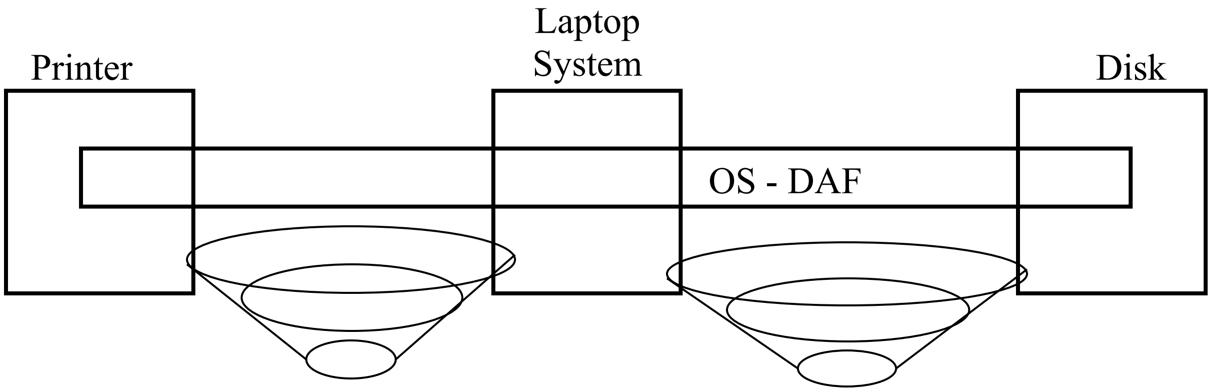


Application and Operating System DMS



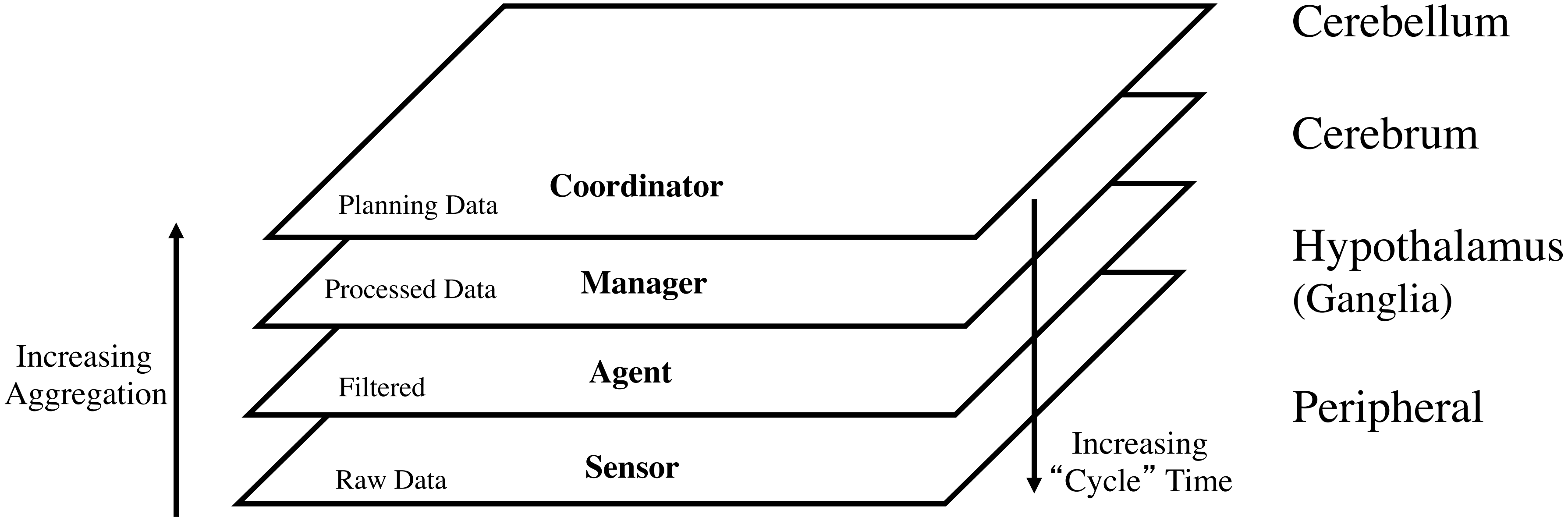
- Application-DMSs will generally be needed for large complex applications and of course, are very application specific, so there is not much we can say beyond the general model.
- A traditional OS is a heterogeneous DAF that includes the peripherals.
  - The traditional device drivers are members of the DAF.
  - In the case of the disk, it might have several members: one, looks like a file system, one that looks like a database, and one that yields track and sector access.
  - And a short step from this to this:

Even More Distributed



- A traditional OS is a heterogeneous DAF that includes the peripherals.
  - Where ever they are.
- Somehow this is much different once you look at the picture.
- An OS is distributed resource manager that in previous years operated under severe connectivity constraints.
- The differences between OS and Network Management becomes a matter of degree.

We Know More About This



- And down the side were the labels
- This became the core of our approach to Network Management

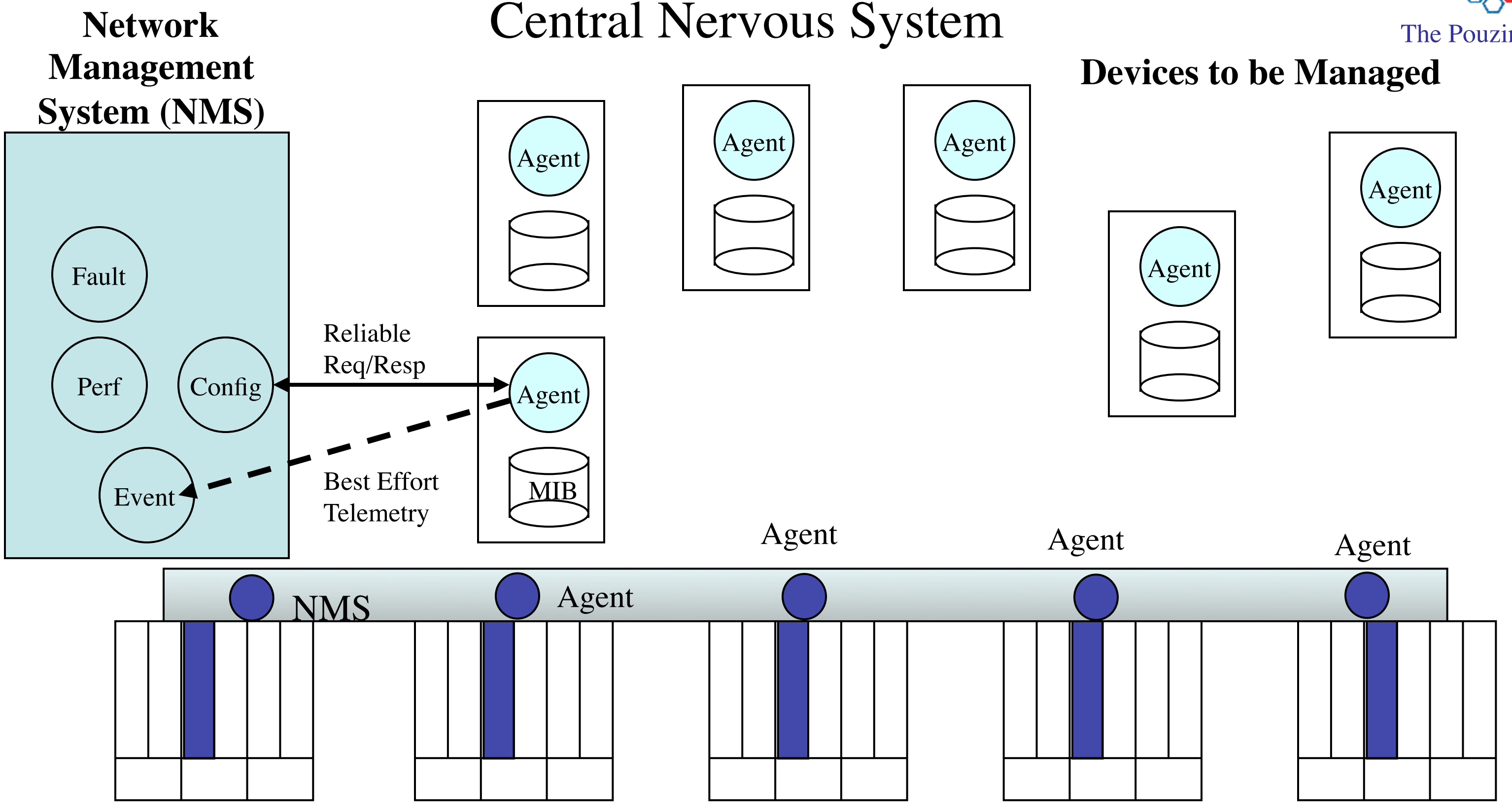
But More Importantly It was Clear that
Network Management is

Monitor and Repair
But not Control

- The whole point is that events are happening too fast for humans to be in the loop. They can manage, but not control.
- Control must be autonomic.

The Management Architecture

Central Nervous System



- While there might be managers for distinct subnets (domains) and the subnets might be a hierarchy, the managers were peers.
  - Many talked about managers of managers but there is really nothing for second level managers to do. (that generalizes?)
- Fault Management isn't an app, it is a management system with a small domain.
- Then Realized what was missing: Where's the Homunculus?

Autonomic or Layer Management

- Clearly Routing was the primary example. It was clear that routing and resource allocation were confused.
  - But there seemed to be so much variation in what the layers did
  - Also resource limitations prevented much practical exploration.

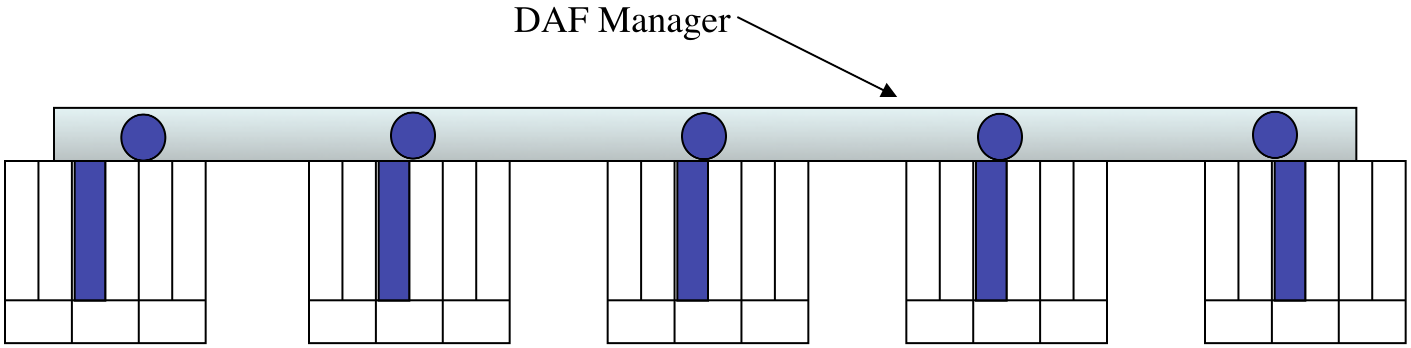
- There are those who believe autonomic is all that is needed:
- This is true, it can be.
  - As long as the complexity never gets beyond that of
  - Mycetozoa, porifera, or coelenterata.
    - slim molds, sponges and maybe jelly fish.
  - It can find local optimal points, but tends to miss global ones.
- But just as in nature, there are interesting configurations along the line from fully distributed to very centralized.

On Autonomic vs Centralized

Or What I remember from taking Invertebrate Zoology

- As the last slide indicates rudimentary central nervous system appears in fairly primitive organisms, such as Platyhelminthes (flatworms).
  - But so do eyespots.
  - Clearly monitoring and reporting must be centralized.
- Some actions can be done without a central nervous system, see coelenterate locomotion and tentacles.
  - Some rhythmic behaviors as well, where reacting to neighbors suffice.
- However, complex actions across the organism may require more coordination, as will finding true optima rather than local optima.
  - In nature, we find that ganglia suffice for this much of the time with ganglia often being larger than the “brain.”
- Food for thought for management.

The DAF Management Model Is Perfect for Exploring It



- Have already seen the traditional centralized configuration.
- Could also have configurations where the functionality of the DAPs was more or less the same, OR
- Where some DAPs served as “area coordinators” or ganglia as they are called providing local centralization.
- This is an area for much further exploration.

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The Most Important Property for Management

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- Commonality, Commonality, Commonality.
  - Reduce the Parts Count.
- Not Necessarily just make everything look alike, but
- Effectively separating the like from the unlike
  - Maximizing invariance and minimizing discontinuities
- Bounding the range of variation (divide and conquer)
- This is what the principles we have uncovered do, and have been
- Embodied in RINA.
  - RINA was not designed to do this. We worked out the principles and then did what they said. (There wasn't that much leeway.)
  - We aren't done. We have pushed commonality into major parts of the model but there are more principles, invariances to find.
    - It is subtle, greatest generality with least constraint, often requires shift in POV

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Name Space Management DSMs

Name Space Management (NSM)

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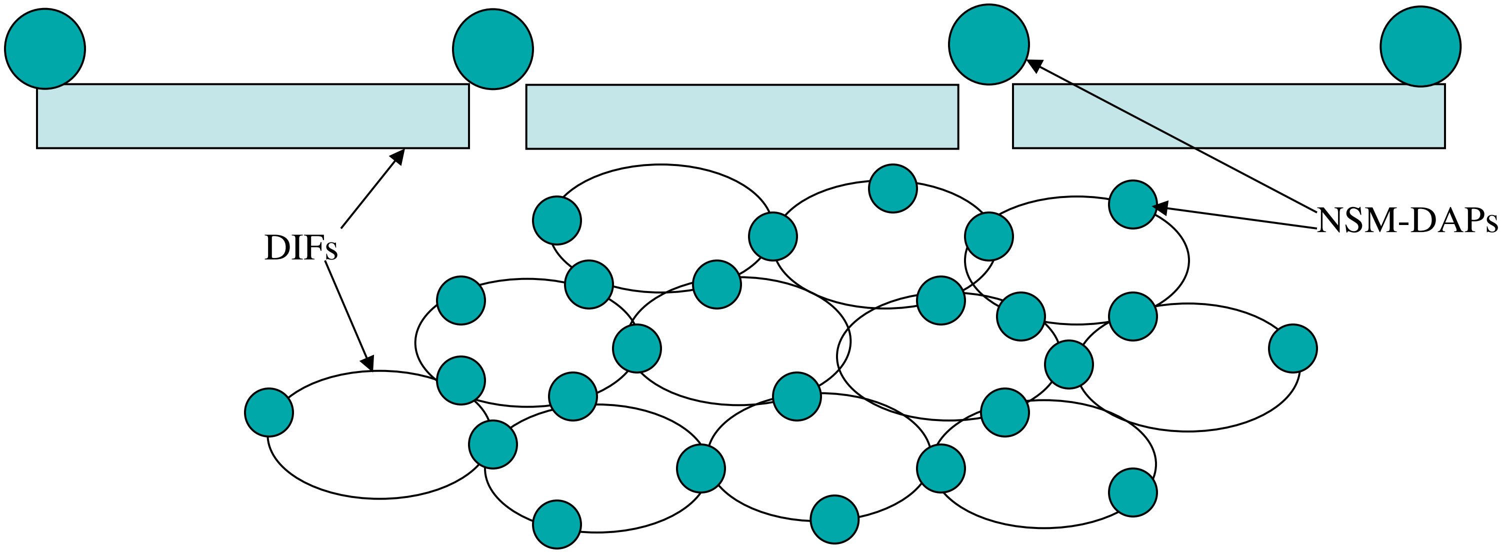
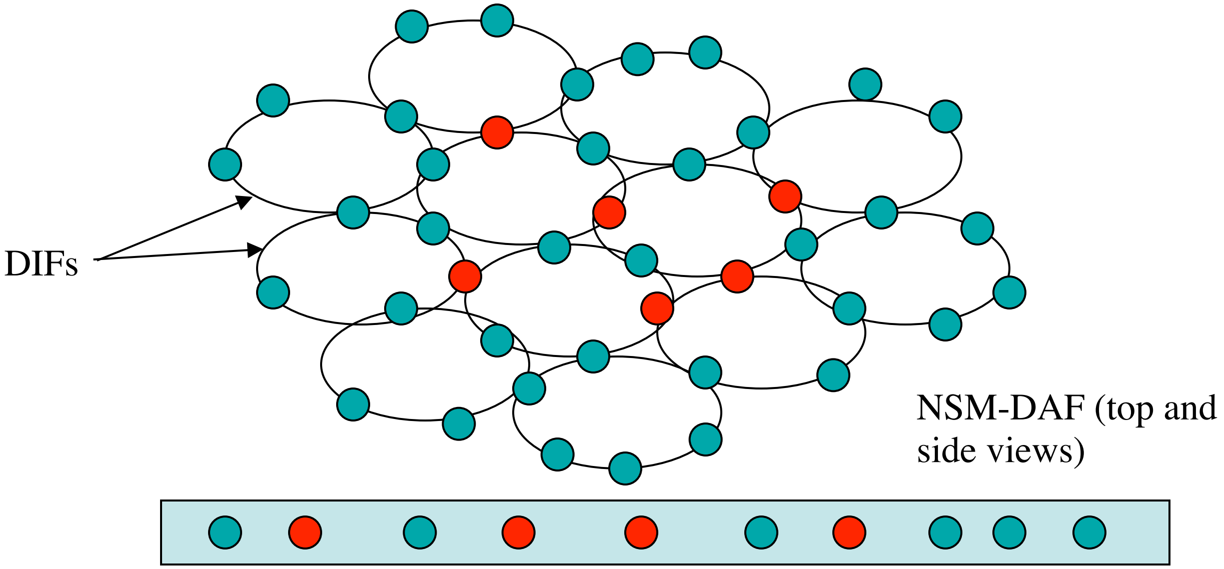


- The IPC Model posits a function that allows the Application Name Space to have a greater scope than any one DIF.
  - Which we have called the Inter-DIF Directory (for lack of a better term)
  - Entity associated with the IPC Management in DAPs may query what applications are available in a system.
  - This forms a graph where the nodes are NSM-DAPs and the arcs are DIFs

NSM-DSMs

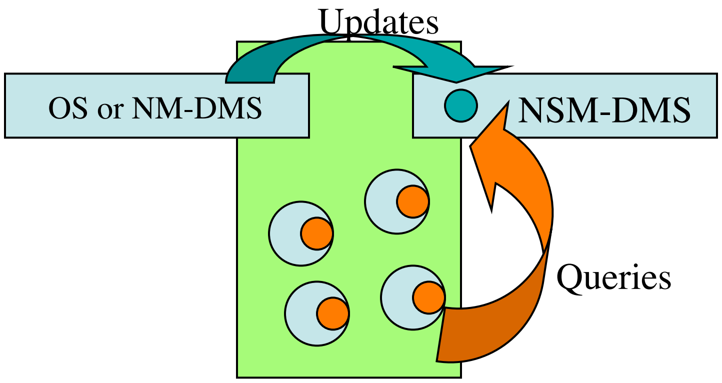
- Considering this a Name Space Management DMS reveals the functions:
  - Authenticate applications that are allowed to query the NSM-DMS
  - Authenticate and authorize entities that are allowed to update or modify the NSM-DMS.
  - Implement the policies for updating and replicating data to meet load and reliability requirements, including creating forwarding tables.
  - Check credentials of a request to determine requestor has access to the requested DAF and if so, return a list of DIFs and supporting DIFs.
  - Manage the name space, determine who gets assigned what.
  - Manage the creation of a common DIF between the requesting and requested DAPs.

NSM-DSMs



- For an environment of any size, we can expect that information on available applications will be organized to shorten search time.
  - Hence some NSM-DAPs will contain only local information: 🔵
  - While others will be repositories for aggregate information: 🔴
    - The repositories might be organized by a hierarchy, DHTs, the Dewey Decimal System, etc.
  - This implies two kinds of forwarding tables:
    - Find the next repository, either aggregate or local. 🔴
    - Forward among NSM-DAPs to get to those repositories. 🔵 🔴

NSM-DSMs

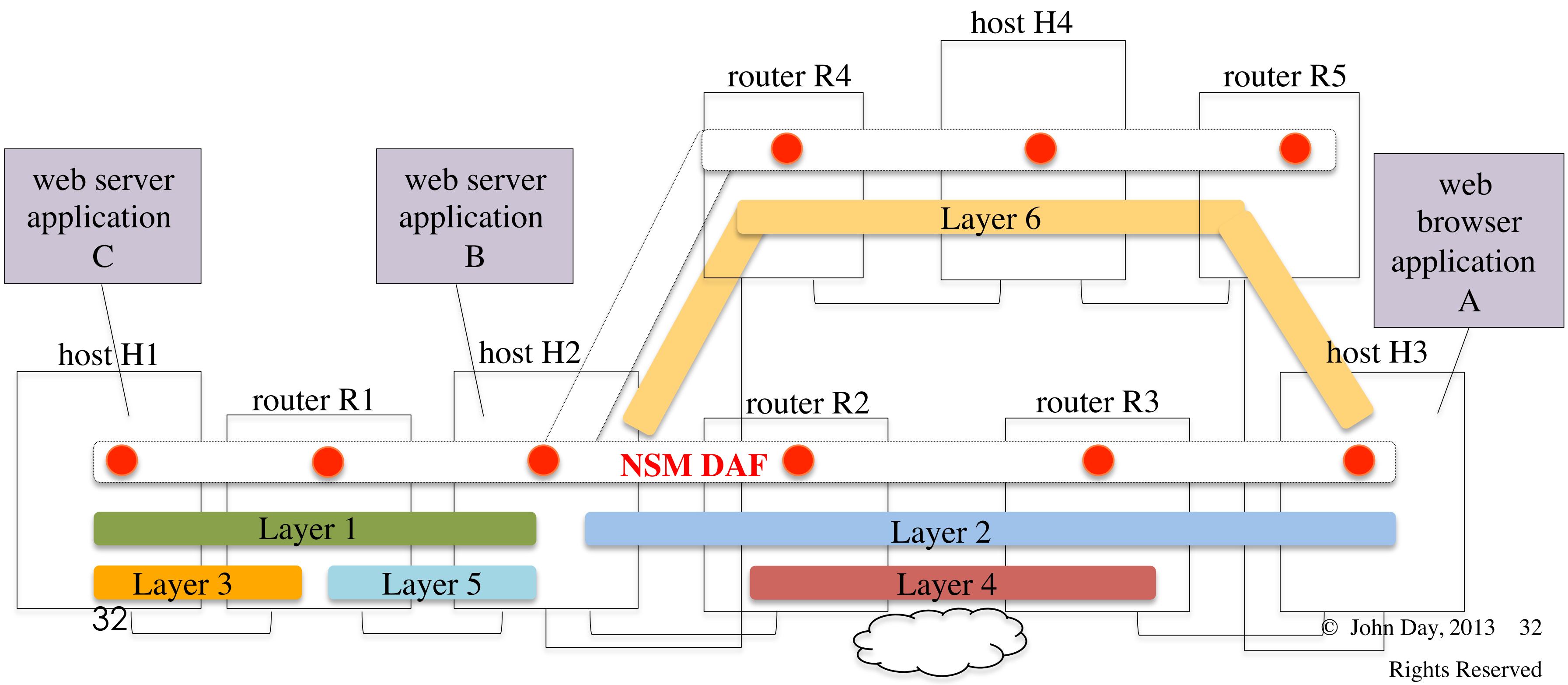


Processing System

- Clearly there is a potential scaling problem here, if we are not careful.
- For large systems, a management system (either an OS-DMS or NM-DMS) will be responsible for access control domains.
  - These DMSs will be authorized to update or modify information aggregated with a NSM-DMS, will provide the local NSM-DAP, and participate in creating or joining new DIFs.
  - Everything else will be a NSM-client only, i.e. can only submit queries.
    - May not be considered a member of the NSM-DAF or a lesser member.
- For small systems, it degenerates into the DAF structure.

Discovery of the application

- Forwarding of the request between the peer NSM-DAPs until the destination application is found or the pre-defined termination condition is met



NSM Information

- Naming / synonyms
- Neighbor Table
- Search Table
- Repository

Search Table

Application Process Name	List of Peer NSM DAP Names

Naming Information

IDD Application Process Name
synomyms (optional)

Neighbor Table

Peer NSM DAP Name	List of Peer NSM DAP Names

Repository

Application Process { Name, Access Control Information }
List of supporting DIFs { Name, Access Control Information, supported QoS }

What the NSM request looks like?

- A CDAP Read Request for an NSM-Record

  NSM-Request

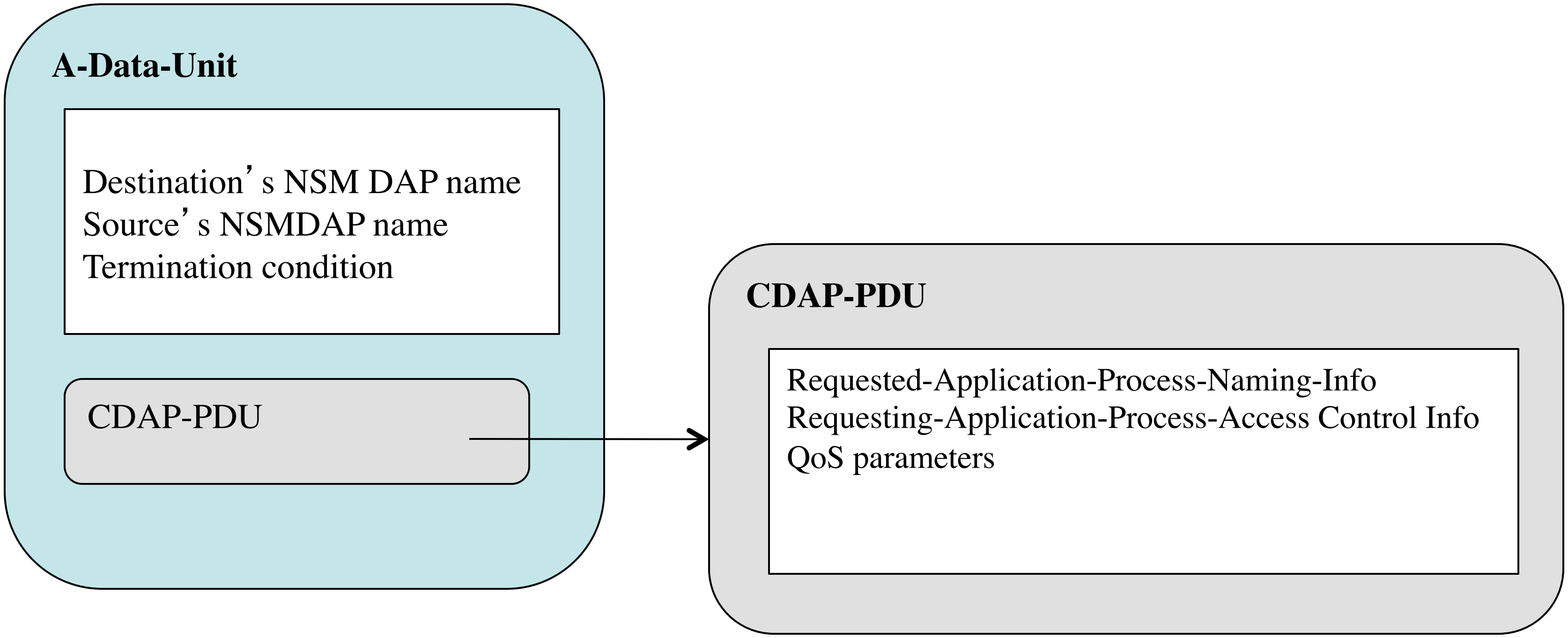
  requested-Application-Process-Naming-Information
  requesting-Application-Process-Access Control Information,
  QoS parameters

- The CDAP Read Request can be encapsulated in an A-Unit-Data

  A-Unit-Data

  destination's NSM DAP name
  source's NSM DAP name
  termination condition (e.g. hop count)
  CDAP-PDU

How is it forwarded?



A-Data-Unit

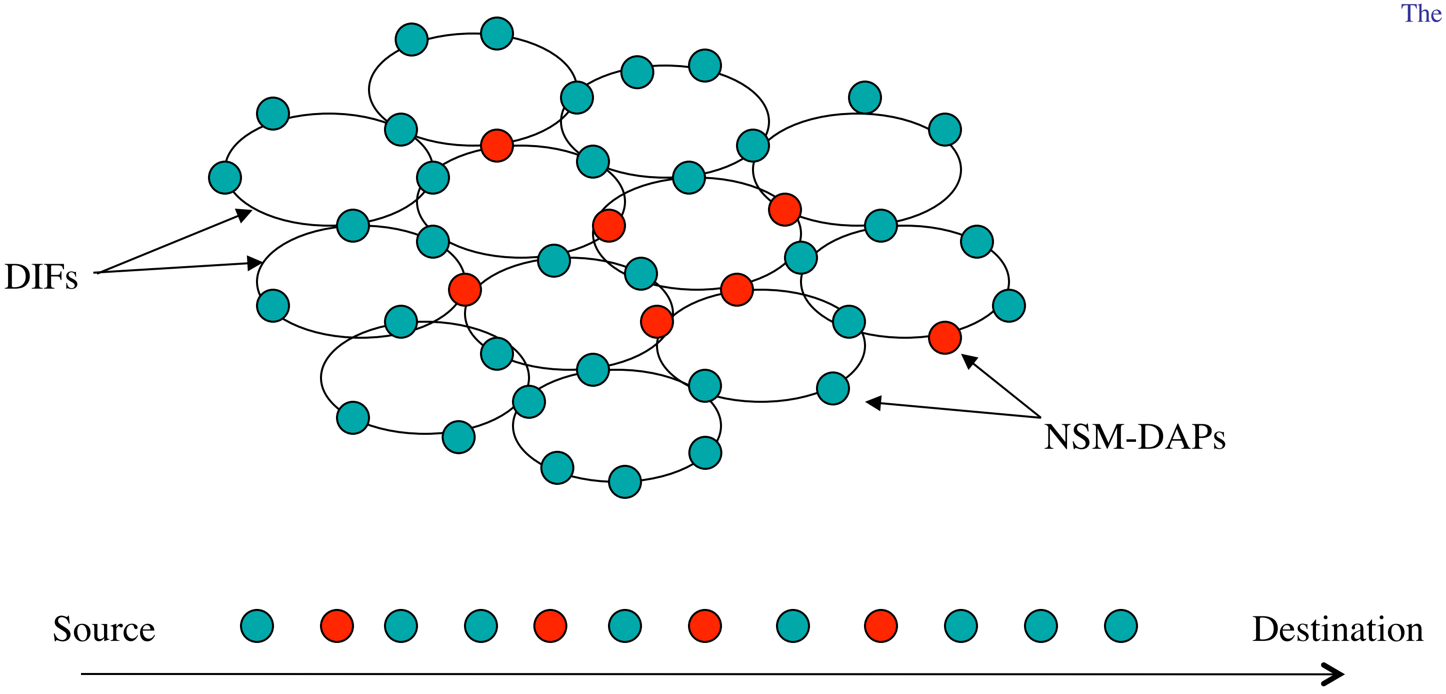
Destination’ s NSM DAP name
Source’ s NSMDAP name
Termination condition

CDAP-PDU

CDAP-PDU

Requested-Application-Process-Naming-Info
Requesting-Application-Process-Access Control Info
QoS parameters

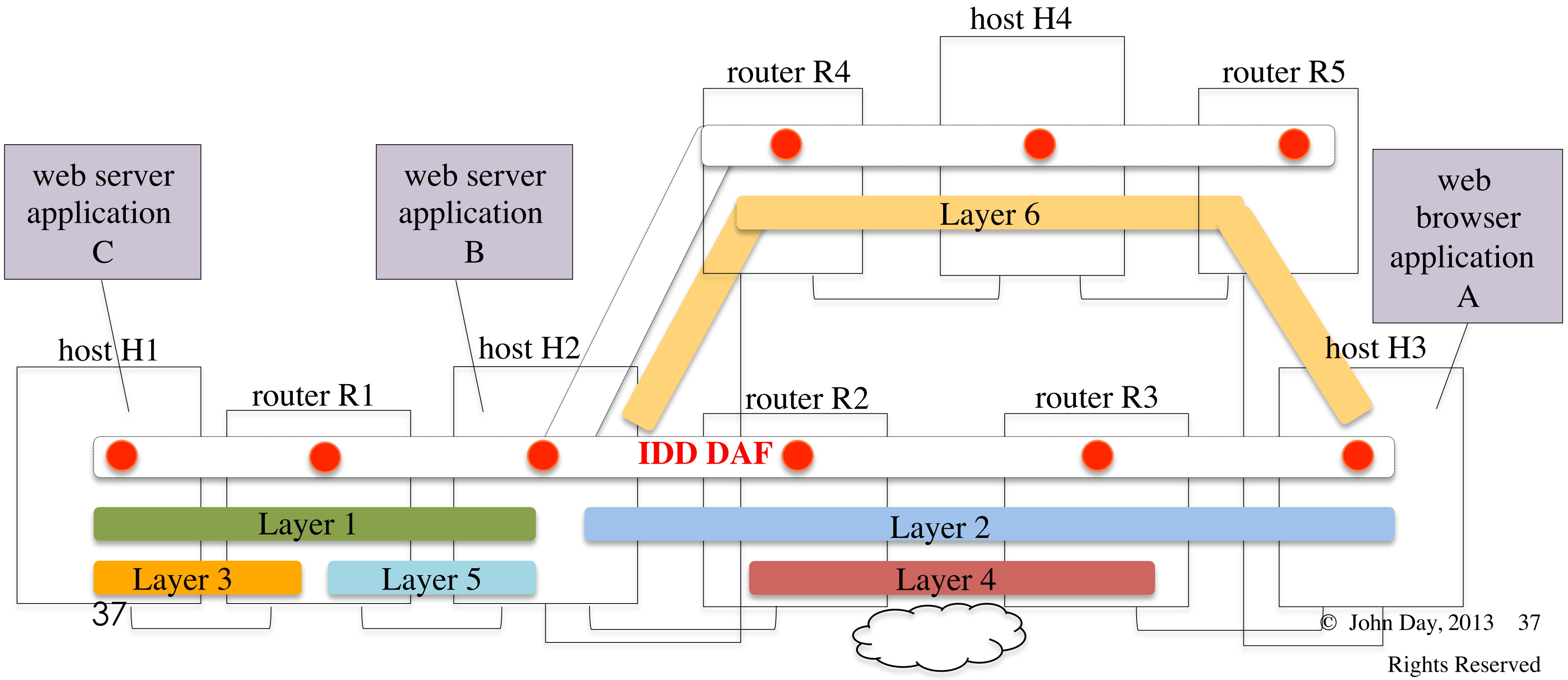
How is it forwarded?



- From any DAP to the other you forward A-Data-Units
- In the first, the last and all the red DAPs you process the CDAP PDU
- Only in the destination NSM DAP (last one) you do a CDAP Read for an NSM-Record

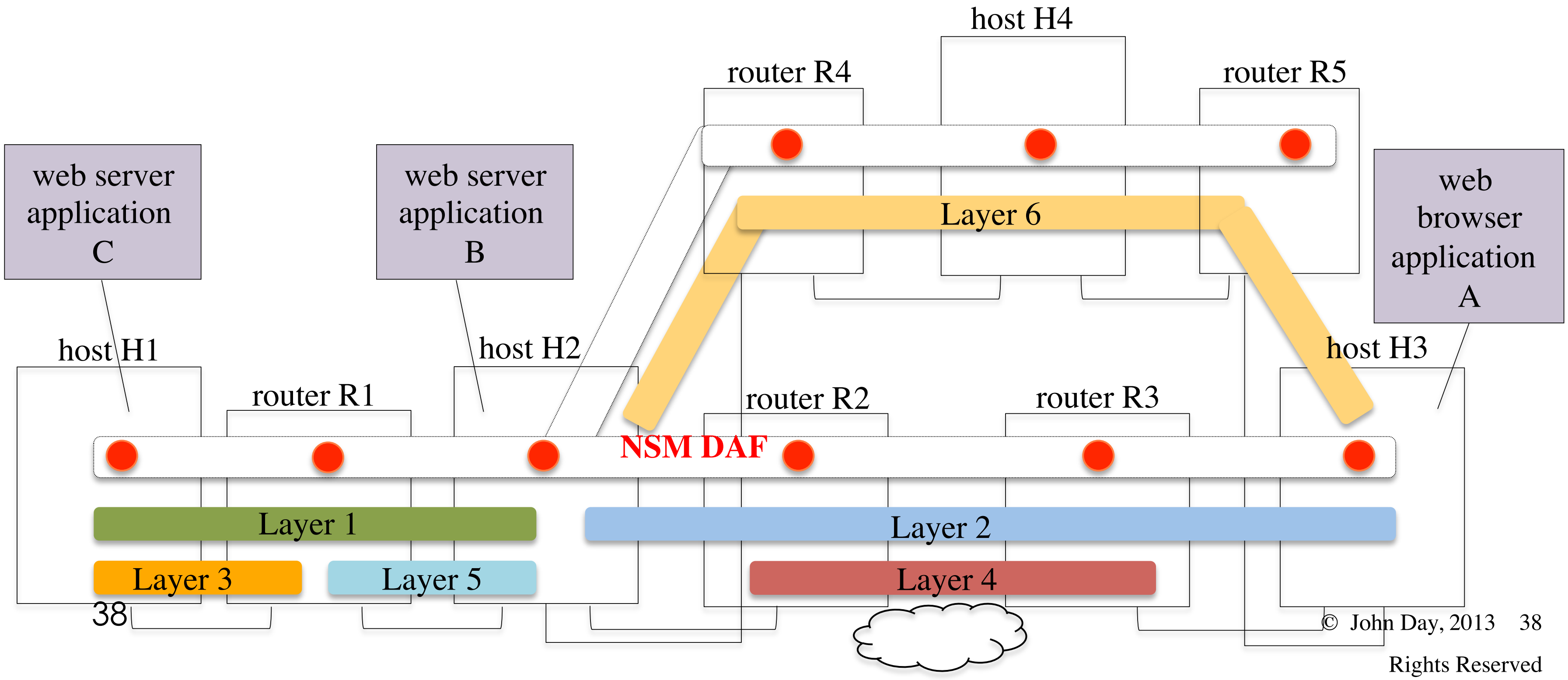
Discovery of the application

- Confirmation that the requested application is available in the destination system and authorization check that the requesting application has the rights to access it



Creation of the supporting DIF

- A DIF supporting the communication between the two user applications has to be found
- This either involves creating a new DIF from scratch or expanding (joining) an existing one so that it spans from the source to the destination system



Implications

- There is no application discovery mechanism in the Internet today, not just pointers to where to search next as today with DNS
- Applications do not have to be in the same layer to discover each other, especially not on the same one layer as with IP
- Elimination of the need for layers with large address spaces
- No need for a single application namespace. Name spaces can be tailored to environments.
- Greater security by having multiple application namespaces and by better compartmentalization without impairing reachability

Another Interesting Pattern

- Notice that the pattern exhibited by the NSM-DSM of:
  - Look up among distributed data bases (NSM-repositories) followed by the creation of distributed shared state (DIF).
- Has precisely the same structure as the Flow Allocator:
  - Look up among distributed data bases (Directory) followed by the creation of distributed shared state (Connection).
- Which has precisely the same structure as Routing:
  - Look up (computation) among distributed data bases (forwarding table) followed by the creation of distributed shared state (routes).
- The first involves with multiple management domains and DIFs
- The second involves possibly multiple management domains and one DIF
- While the third is one management domain and one DIF.
- There may be another collapse here.

Questions?