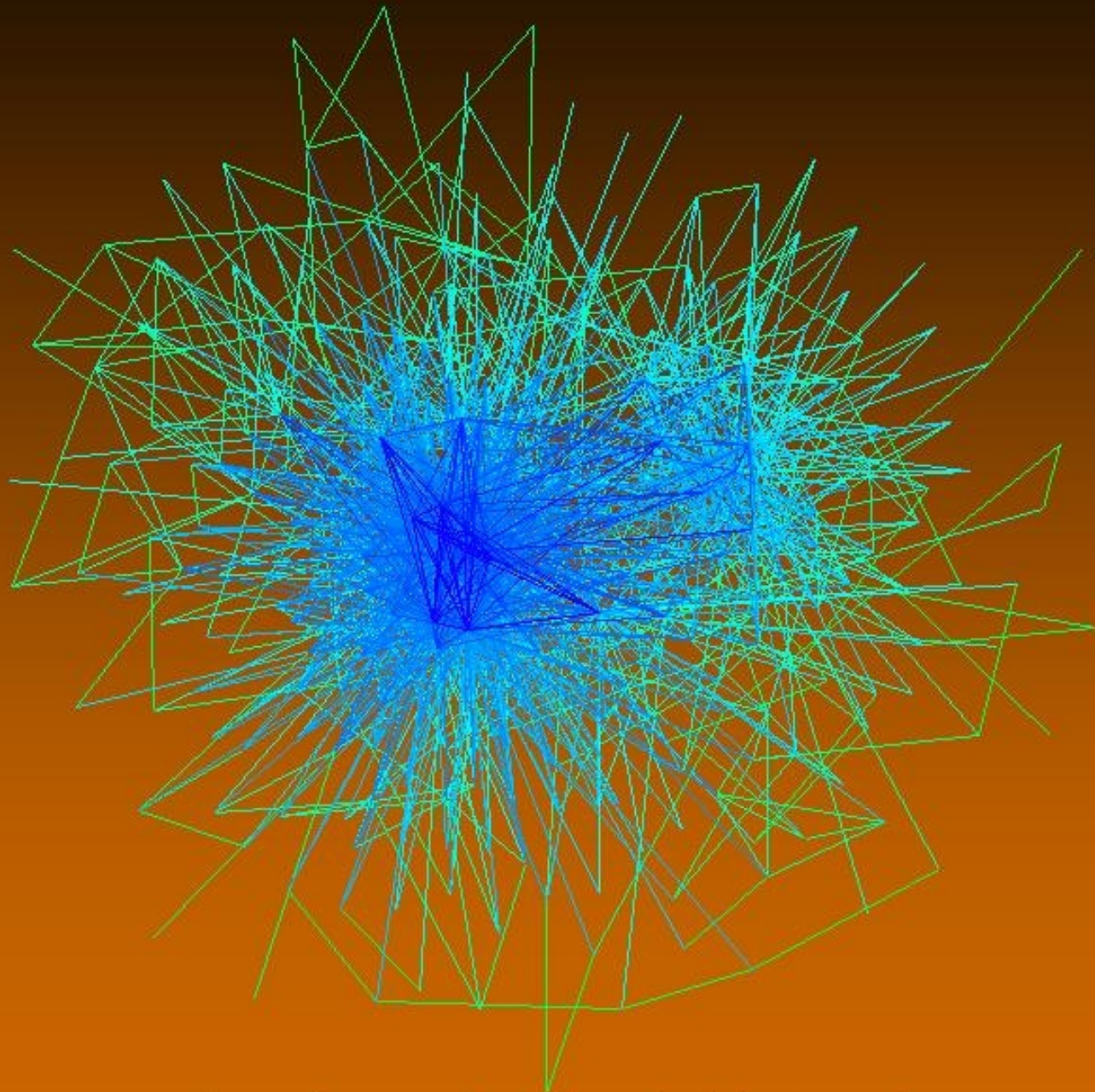# Nimrod Routing
Feedback Based Routing

Distributed Computing Seminar

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A subgraph of a BGP graph

Summary

- Limitations of actual routing system

- Feedback based routing (protocol)

  - Security, Fault tolerance

  - Scalability, Rapid convergence

- Nimrod routing (architecture)

  - Security, Scalability, New Features

  - Deployment

Actual Routing protocol

- Border Gateway Protocol - BGP

  - Distance vector

  - Hop-by-hop

  - All routers collaborate

What's wrong with that?

- BGP

  - Distance vector

    - Grows exponentially

    - Slow convergence time

  - Hop-by-hop

    - No control on the route by users

  - All routers need to collaborate

    - Tables must be consistent

Feedback Based Routing

- New routing protocol

- Link state
  - Distinguish structural and dynamic information

- Edge: routing decisions and measurements

- Core: propagate information and forward packets

Routing information

- Structural

  - Existence of links

  - Propagated to the edge of the network

- Dynamic

  - Quality of paths

  - Not propagated, but measured

Access and Transit

- Access routers

  - at the border of edge networks

  - select routes

  - insert Internet Relay Tokens (IRT)

- Transit routers

  - at the border of autonomous systems (AS)

  - don't compute routing tables
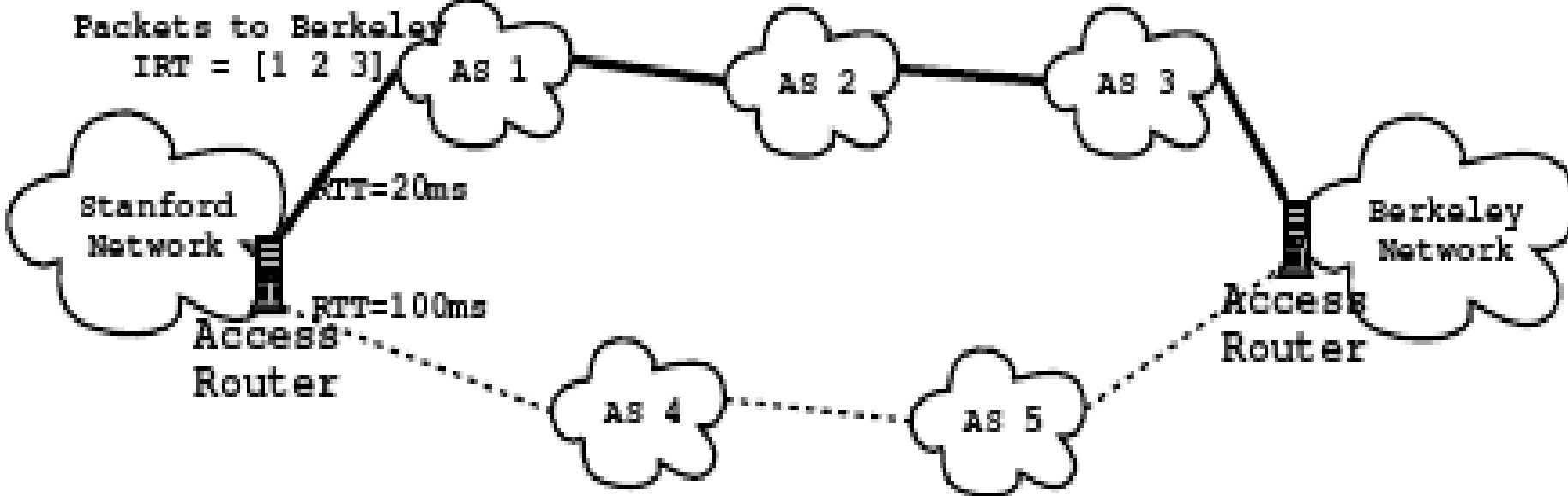
  - forward packets with respect to IRT

Normal route
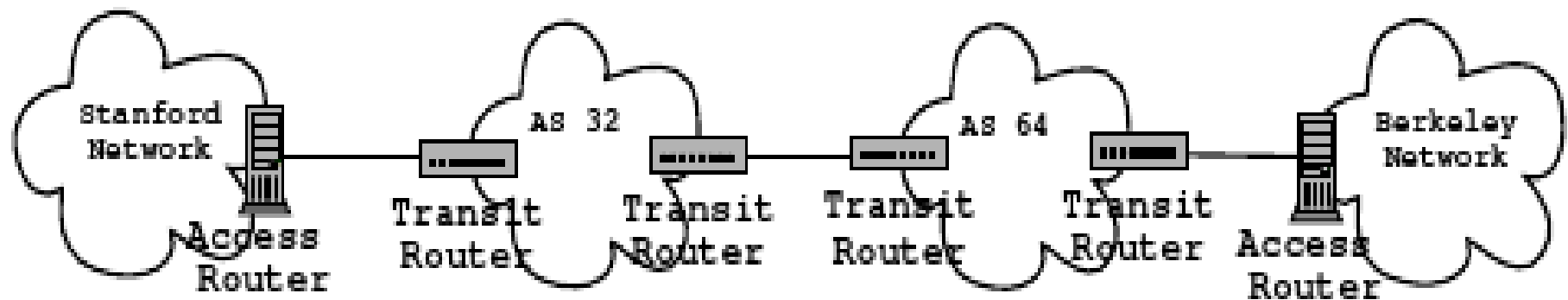
Feedback algorithm

- Compute two routes to every network prefix

    - disjoint routes

    - exclusion of bad-links

- Monitor the quality of the routes

    - assign expiration time

    - sample round trip time (RTT)

- Define primary and backup routes

New Routes

Security

- Access routers always monitor the route

    - avoid black holes and bad links

    - public key to authenticate the routers

- Problems in monitoring

    - bogus TCP answers: SYN / SYN-ACK

Scalability

- Route computation is moved to the edge

    - no need to compute shortest path in core routers

- Messages reduction: only structural changes

- Transit routers

    - independent from number of address prefixes

    - can limit resources

What can be better?

- Policy routing

  - provider restrictions (cost, services, accounting)

  - user requirements (quality, provider)

- Mobility of endpoints

- Different types of communication media

  - throughput, delay

  - privacy

Nimrod

- Perfection is attained not when there is no longer anything to add, but when there is no longer anything to take away.

  Antoine de Saint Exupery

- One ring to rule them all, one ring to find them, one ring to bring them all, and in the darkness bind them.

  J.R.R. Tolkien

Nimrod Routing

- Nimrod: it might run one day

- RFC 1992, many other documents

- Year 1996

- Routing Architecture

Architecture vs Protocol

- Architecture provides

  - a model to understand the internetwork

  - description of functionalities and interactions

- Architecture doesn't provide

  - definition of the protocols

  - definition of the algorithms

Goals

- Policies
  - access control
  - trust model
  - information hiding
  - accountability
- Service specific routing
  - best-effort, pay service
  - user requirements, provider restrictions

Goals

- Support dynamic internetwork

  - arbitrary size

  - control routing information

  - user-controlled routes

- Incremental deployment, interoperable changes

- Vendor independant

Architecture

- Node

  - region of the internetwork

  - host, continent, process

- Adjacency

- Map

  - graph composed by nodes and adjacencies

  - used for routing

  - different levels of abstraction

Architecture

- Endpoint Identifiers (EID)

  - identify host or user

  - globally unique

  - no topological significance

- Locators

  - identifies a location

  - hierarchical
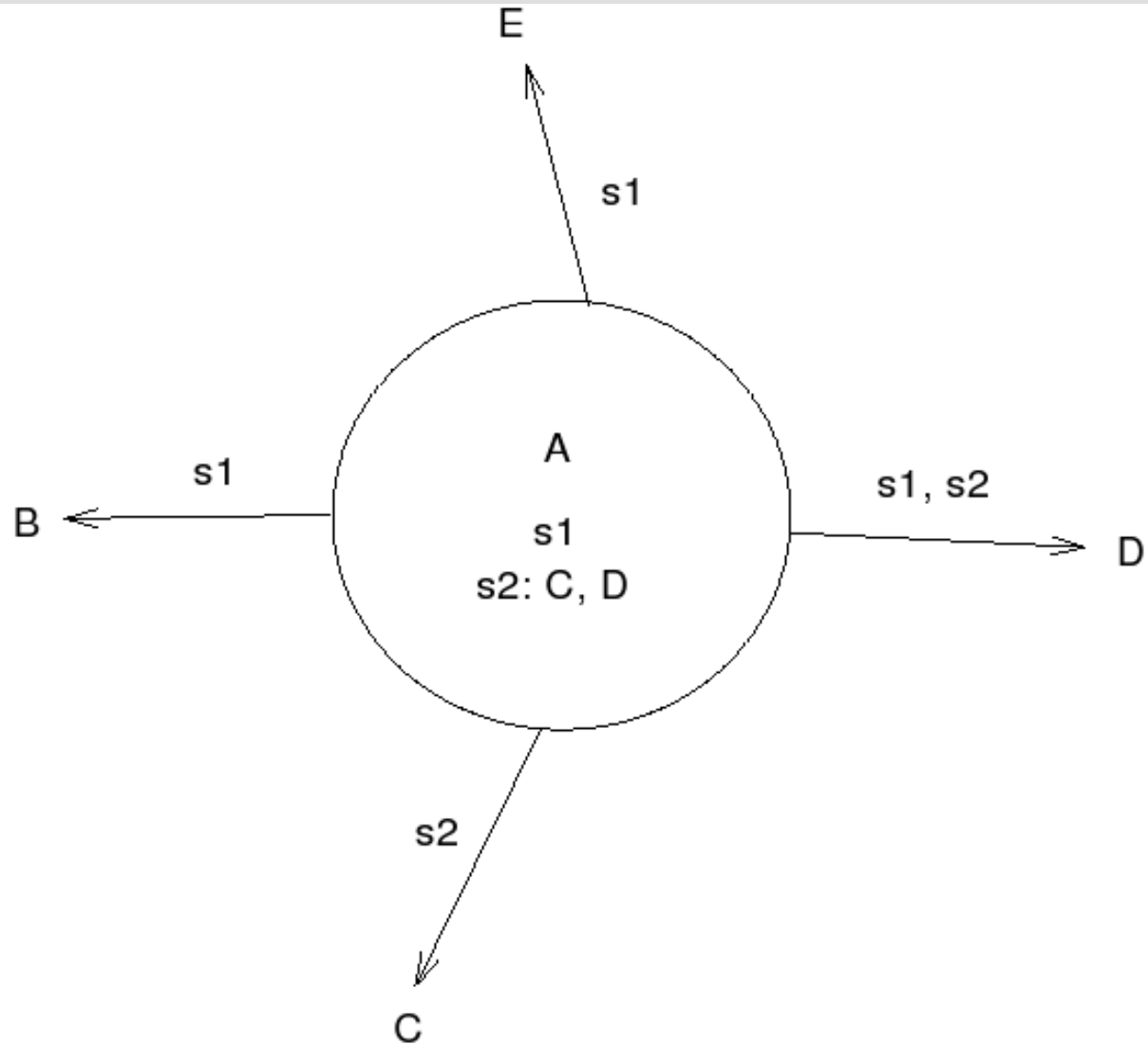
  - used for routing decisions

Raw Map
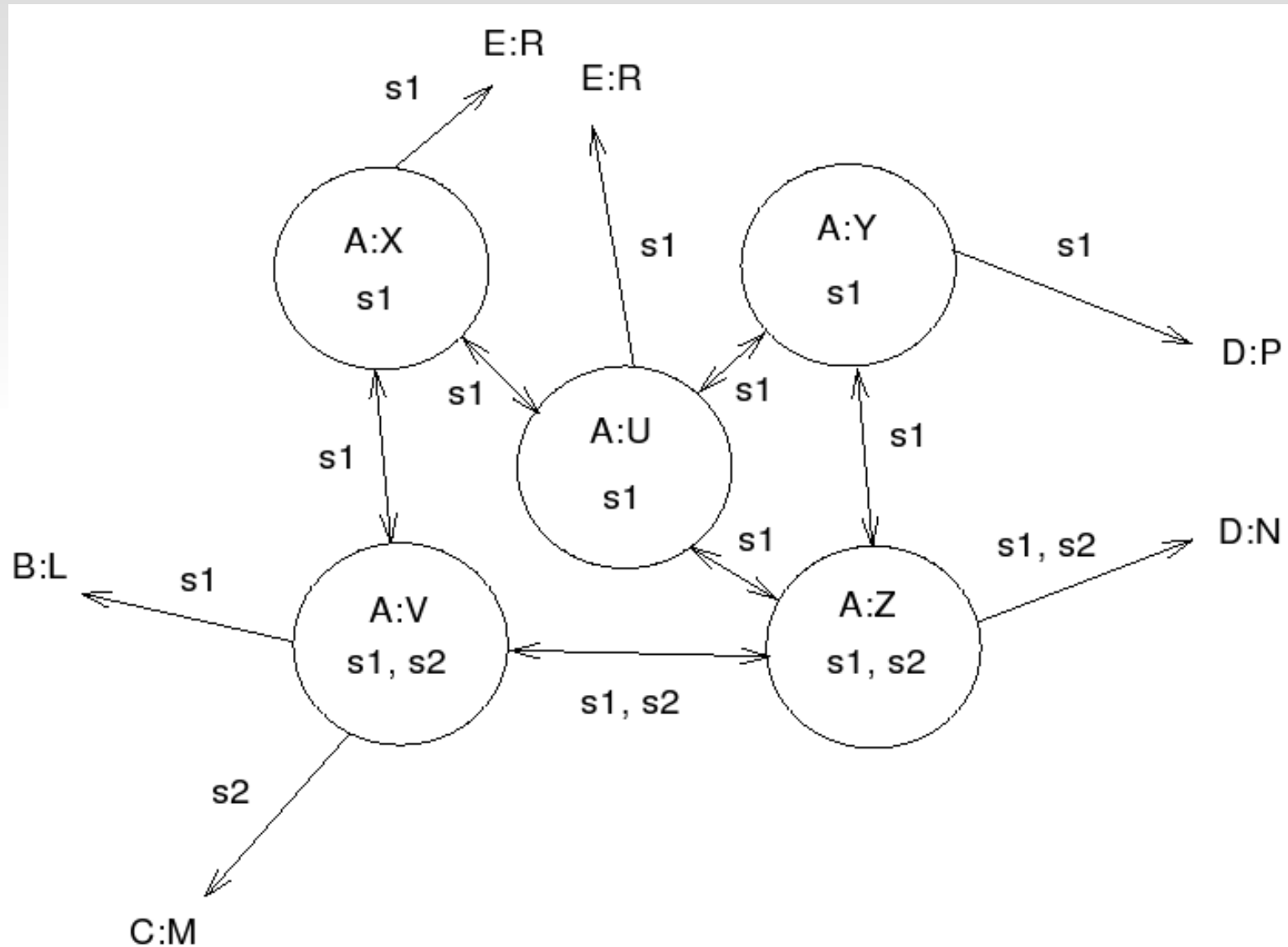
Scalability

- Clustering

  - reduce the number of visible entities

  - hierarchy with unique universal root

  - must satisfy connectivity

- Abstraction

  - reduce the amount of information

- Either algorithms are not imposed by Nimrod

Abstract Map

Scalability

- Information hiding

  - each node decides what information to disclose

  - advertising of specific portions

  - advertising to specific users

- Limit forwarding information

  - multiplex traffic flows

  - install information only for active flows

Scalability

- Local selection of routes

  - compute special routes only if needed

  - protocol not imposed by Nimrod

- Caching

  - temporary routes used to generate the final ones

  - expected duration of useful information

Forwarding

- Connectivity Specification Sequence

    - sequence of nodes to visit

    - doesn't specify physical path

- Connectivity Specification Chain

    - continuous list of nodes to visit

   - doesn't specify physical path

Forwarding

- Flow mode

    - initially installs a path in the routers

    - for each packet, just follow the installed instructions

- Datagram mode

    - every packet carries source and destination locators

    - no information is saved in routers

Nimrod Agents

- Entity representative
  - entity attributes
  - assign locators

- Route agent
  - collect maps
  - generate routes

- Association agent
  - answer queries
  - propagate information

- Forwarding agent
  - initiate relationships
  - request routes

Example of Path Setup
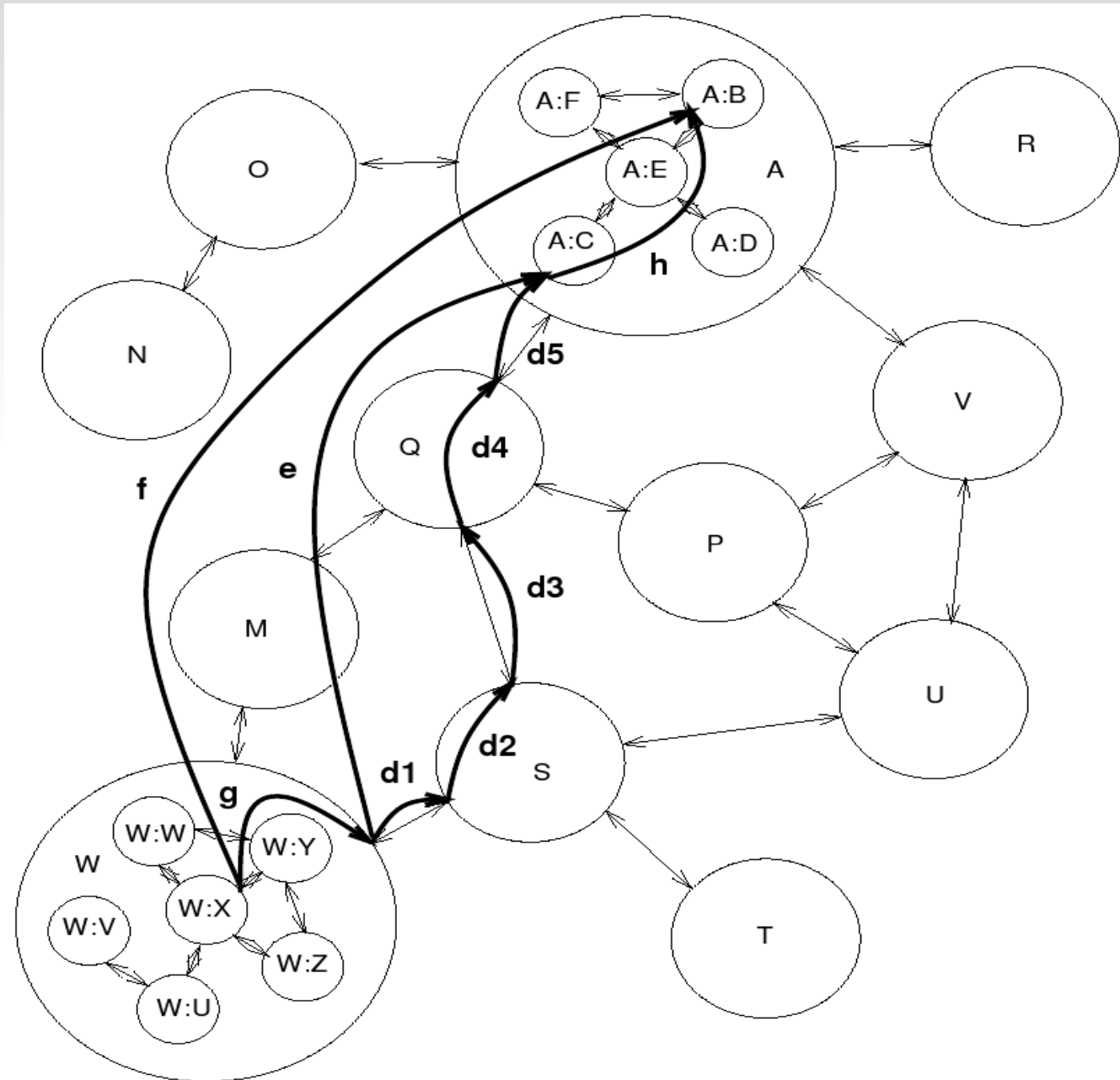
Conclusions

- Feedback based routing

  - routing resources independent from network size

  - offer better convergence times

  - solves some security issues

Conclusions

- Nimrod provides a new architecture

    - based on actual and future requirements

    - provides base for diversity (networks, services, ...)

- Transition is taken into account

    - can be integrated with actual architecture

    - changes are interoperable

    - vendor specific algorithms

Criticisms

- Feedback based routing

  - Addressing needs

  - End-to-end principle

  - Lack of support for new features

Criticisms

- Nimrod deployment

  - IP as locators and EID?

  - Global registries

  - Implementation

Nimrod Software Modules for All Agents
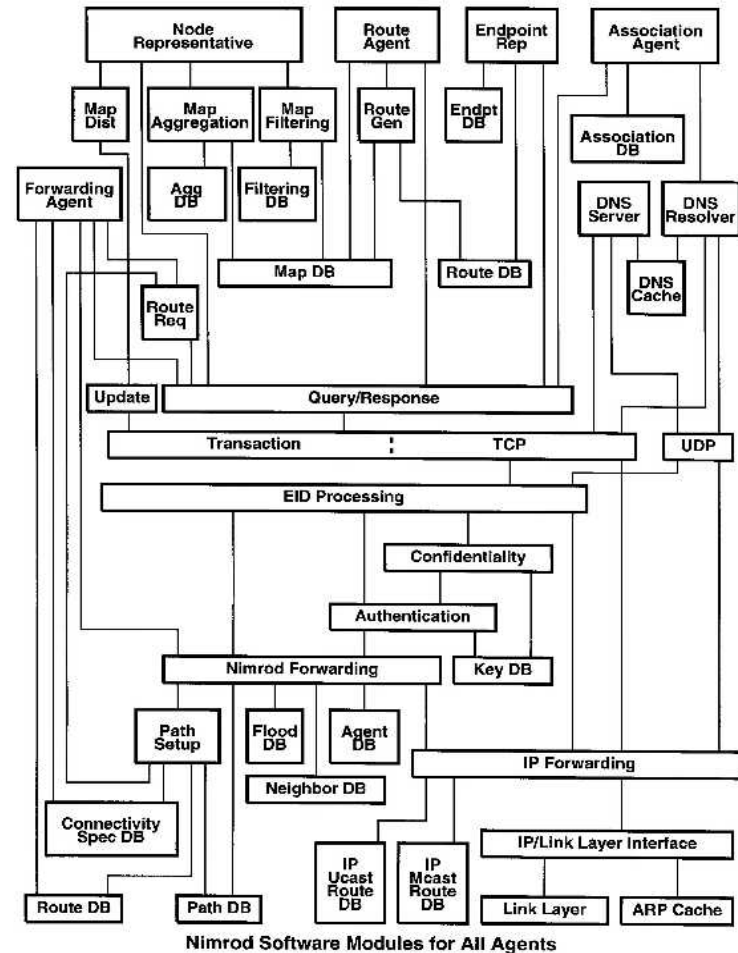
Questions?

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Nimrod Routing
Feedback Based Routing

Thank you