# Routing in a Multi-Provider Internet

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# Current Environment

Multiple Network Service Providers (NSPs) driven by diverse and sometimes even conflicting goals and objectives:

- Mission oriented NSPs (e.g. NSI)
- Commercial NSPs (e.g. Alternet, PSI, etc...)
- An NSP may constrain reselling connectivity
- An NSP may be subject to regulations
- Wide variations in the scope of geographical coverage

# Current Environment (cont.)

- No centralized control over NSPs
- NSPs don't alway coordinate with each other
- Competition among NSPs

# Current Environment (cont.)

Despite the diversity among NSPs, Internet-wide connectivity requires certain degree of cooperation and coordination among NSPs.

Need to balance the NSPs' goals and objectives against public interest of Internet-wide connectivity and subscribers' choices.

# Routing Requirements

- Conceptual taxonomy
  - Source preferences
  - Destination preferences
  - Transit traffic constraints
- Wide variability with respect to the degree of control
  - What are the most important requirements ?

## Routing Requirements(cont.)

Support for a routing requirement doesn't come for free

- Who bears the cost ?
  - ideally should be shifted towards the entity that instigates the requirement
  - an organization shouldn't unilaterally impose burden on other organizations
  - need to perform cost/benefit analysis associated with a requirement
- Ability of an organization to instantiate its routing requirements in a more or less central (to the organization) fashion

# Scalability

- Ability to scale – key requirement for the Internet routing system
  - CPU, memory, bandwidth
  - human resources
- System that scales linearly with the number of networks or even sites
  - unacceptable today (CIDR is the best proof)
  - unlikely to be acceptable in the future
- Can we operate with a system that scales linearly with the number of providers ?
  - how does the number of providers grow with the number of sites ?

# Scalability(cont.)

Scalability implies information aggregation/abstraction

- Need to impose minimum preconditions
- Need to limit the amount of required inter-provider coordination
- Information aggregation/abstraction implies losses of information
  - impact on route optimality
  - impact on the ability to find a route
- Aggregation/abstraction implies certain homogeneity – needs to be balanced against potential diversity of routing requirements

# Scalability(cont.)

- Overhead due to routing requirements and its impact on scalability
- Need to explore mechanisms to acquire routing information "on demand"

# Hierarchical Routing

- CIDR is a realization of hierarchical routing
- To provide routing information reduction Network layer addresses must be "topologically significant"
- Changes in the network topology may require changes in the IP addresses ("renumbering")
  - changing providers
  - need tools to facilitate renumbering
- Multi-layer hierarchy allows to recapture routing entropy
- Hierarchical addresses are not a MUST – large organizations can have their own address prefixes carried through the Internet

# Encapsulation

Allows to create a "virtual" IP overlay

- Where is the source address (outer or inner header) ?
- Where is the destination address (outer or inner header) ?
- What is the semantics of transit policies ?
- What is the semantics of source preferences ?
- What is the semantics of destination preferences ?

# Routing Information Sharing

- Internet-wide coordination is going to be more and more difficult to achieve
- Sharing information about organization's routing requirements could benefit stability and consistency of Inter-wide routing
- Role of Routing Registries

# Conclusions

- Presented some, but not all, of the issues
  - multicast routing ?
  - routing in presence of mobile hosts ?
  - routing in presence of large shared media (e.g. ATM) ?
- Impact of multi-provider Internet goes beyond routing (e.g. network management)
- Need to understand interaction among all the areas involved from a system-wide perspective