

**ΟΙΚΟΝΟΜΙΚΟ
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ΑΘΗΝΩΝ**



**ATHENS UNIVERSITY
OF ECONOMICS
AND BUSINESS**

Information-Centric Networks

Section # 7.2: Evolved Addressing & Forwarding

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Department: Informatics



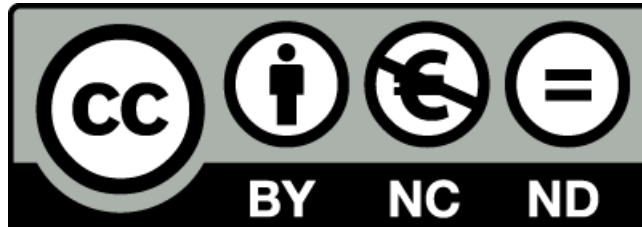
Funding

- These educational materials have been developed as part of the instructors educational tasks.
- The **“Athens University of Economics and Business Open Courses”** project only funded the reformatting of these educational materials.
- The project is being implemented as part of the Operational Program “Instruction and Lifelong Learning” and is co-financed by the European Union (European Social Fund) and national funds.



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Week 7 / Paper 2

- NIRA: A New Inter-Domain Routing Architecture
 - Xiaowei Yang, David Clark, Arthur W. Berger
 - IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 15, NO. 4, AUGUST 2007
- Main point
 - Users choose ISPs but ISPs choose routes
 - What if users could choose provider level routes?
 - How do you discover routes?
 - How do you represent routes?
 - How do you switch routes quickly?
 - How are providers compensated?
 - NIRA represents routes as a sender and receiver part
 - Each part is represented as a single address

Introduction

- Consider routes at the AS level
 - Users select ISPs only
 - ISPs interconnect independently
- Why have users control routes?
 - With cable against DSL local competition is very slim
 - Route selection introduces competition at the top level
 - Gives backbone ISPs an incentives to invest
- BGP selected routes are not always the best
 - For almost 80% of paths, better ones can be found
 - Even more opportunities for multihomed hosts
 - Users know whether they prefer (say) latency or bandwidth
- NIRA provides route selection at the domain level
 - More manageable than the router level

Design overview

- Basic concepts
 - A user can only select routes for which he pays for
 - Route consists of sender, core and receiver part
 - Source and destination part represented as a single address
- Design rationale
 - Users need to discover failure free routes
 - Routes must be encoded into packets
 - Providers must be compensated
 - Assume bilateral contracts between providers
 - Contracts are typically customer-provider or peer-to-peer
 - Tier-1 providers do not purchase transit from others
 - The Internet core consists of the Tier-1 providers

Design overview

- Route discovery
 - Users can only see their providers, recursively up to the core
 - Including the peering connections outside the core
 - This is the up-graph of the user
 - Represented as one route per domain and one link between domains
 - Topology information propagation protocol (TIPP)
 - TIPP path-vector component
 - Advertises reachability towards the core
 - Tier-1 providers advertise themselves, customers attach themselves
 - TIPP link-state component
 - Advertises network dynamics within provider hierarchy
 - A sender combines an up-graph and a reverse up-graph
 - Valley-free routes: upward, horizontal, downward

Design overview

- Efficient route representation
 - NIRA encodes a path through an up-graph into a single address
 - Both sender and receiver fit into single addresses
 - Each Tier-1 provider obtains a globally unique address prefix
 - This is subdivided to its customers, recursively
 - The final address encodes all the providers it is using
 - NIRA uses 128 bit IPv6 addresses
 - 96 bits encode the up-graph and 32 bits a host in the ISP
 - Could instead use a sequence of IPv4 addresses
 - Peering links use a private address space
 - They are also recursively allocated to customers
 - Each host eventually obtains a set of addresses
 - Each address encodes a path to the core or to a peering domain

Design overview

- Bootstrap communication
 - How do you find out the receiver's addresses?
 - Need to select a path for the receiver too!
 - NRLS: maps names to route segments
 - Similar to DNS but returns multiple up-graphs
 - Hosts are notified by TIPP about network changes
 - They may then need to notify NLRS about their routes
- Handling route failures
 - TIPP notifies the sender but not the receiver
 - If a route is unavailable, the routers return ICMP errors
 - Local errors are masked in domain level paths
 - Inter-domain errors are passed to the sender for a decision
 - The sender consults the NLRS again to choose a new route

Design overview

- Choosing routes
 - A user agent runs on each user's computer
 - The agent combines sender and receiver parts
 - Depending on preferences it chooses a combination
 - Subsequent packets can be used to switch to another route
- Forwarding
 - The up-graphs and reverse up-graphs are specified
 - The route through the core is not specified
 - Tier-1 providers retain control of these routes
 - Users are not exposed to the dense backbone connectivity
 - Each Tier-1 provider needs to advertise a single prefix
 - Any ISP (not only Tier-1's) can decide to join the core
 - It simply needs to obtain a global prefix

TIPP

- TIPP runs between domains but not in the core
 - Separate address and topology propagation
 - Propagating address information
 - A provider announces address prefixes to customers
 - Customers recursively propagate these announcements
 - Propagating topology information
 - Link-state protocol with policy controls
 - Scope enforcement: limit what neighbors know about customers
 - Information hiding: limit what neighbors know about neighbors
 - Uses the Shortest Path Topology Algorithm (SPTA)
 - Computationally more expensive than OSPF or IS-IS
 - But easier to resolve inconsistencies between different messages
 - Should be sufficient for the small scale of the upgraphs

Forwarding

- What is the next hop towards a destination address?
 - Three tables are maintained at each router
 - Uphill: points to the provider that allocated each prefix
 - Downhill: points to the customer that received each prefix
 - Bridge: points to the neighbor allocated with each private prefix
 - Separate from other routing tables (for core routers)
 - Lookup destination in downhill table
 - Lookup source in uphill table
 - Special entries in uphill table
 - Routing: forward through the core
 - Bridge: forward via bridge table (to peer)
 - Special entries in downhill table
 - Blackhole: drop packet (customer is disconnected)
 - Self: forward packet inside the domain

Evaluation

- Amount of state obtained from TIPP
 - The up-graph can grow exponentially
 - Provider hierarchy is not fully known, but inferred
 - Statistics for 90% of domains
 - Less than 20 addresses prefixes
 - Less than 30 link records
 - Less than 100 forwarding entries
- Message overhead and convergence speed of TIPP
 - Less than 1 sec to converge after link failure/recovery
 - Less than 2 messages per link failure/recovery
- Setup latency due to reactive failure detection (ICMP)
 - 80% of connections need a round trip
 - 99% need three round trips

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End of Section # 7.2

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