XIA: Lessons Learned and Open Issues

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Outline

• Evolvability and friends
• Network evolvability
• Headers and DAGs
• Making it work
Evolvability Lessons

• Mechanisms are effective in supporting evolvability
  – Starting with NID and HIDs, added CIDs (content), Scion IDs (path based forwarding), 4IDs (legacy IP), anycast SIDs; working on RIDs, CID variants

• But evolvability mechanisms support other important usage models
  – Customization of networks
  – Discovery function
  – Selective and opportunistic deployment

XIA Supports Network Diversity

• XIA in public Internet:
  – Core networks: NID only
  – Eyeball: NIDs plus some value-added services
    • E.g., CID and SID
  – Customer networks can be very diverse
    • Possibly many XIDs

• Edge networks can introduce custom XIDs
  – Unique forwarding or security requirements
“Fetch” XIDs Support Discovery and Retrieval

- XID first discovers desired destination
  - Anycast, CID, RID
  - Fetch as opposed to send
- Communication session is point to point
  - We use unicast communication (NID/HID)
- Change of end-point addresses is signed
  - Uses intrinsic security

Selective and Opportunistic Deployment

- XIDs can be deployed selectively
  - Business incentives
  - E.g., caching near edge
- Entries can be advertised selective
  - Performance driven
  - Business agreements
  - Custom routing protocols!
- Fallbacks eliminate penalty by allowing in-network recovery
  - Ok to fail
Evolvability Discussion and Issues

• XIDs can represent wide range of “things”
  – Forwarding semantics to “destination”; path-based forwarding; embedding of arch. concepts
• In-network error recovery using fallbacks is very powerful
  – Failures, opportunism, ...
• Intrinsic security has been relatively basic
  – Based on public keys, hashes; maybe signatures?
  – Original definition probably too strict

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Goal is Network Evolvability - Network layer not sufficient

• Observation: BGP has not changed much
  – Last revision is early 90’s
  – Proposed extensions are hard to deploy
• Lots of progress in congestion control
  – But has to be TCP-friendly, defined in ad hoc way
• Socket API has changed ... by adding new calls
  – Old calls never go away, e.g., ftp
  – Address type is exposed to application

What Interfaces Do We Care About?
Key Interfaces - Important and Hard to Modify

- Network layer: header defines an interface
  - Focus so far: “DAG” destination addresses -> rest of the header?
- Control plane protocols: BGP, ICMP, ...
  - Defines how ISPs advertise routes, report errors, ...
- Congestion control: AIMD/TCP friendly
  - Other transport functions are end-end
  - Past work on FCP – evolvable congestion control
- Socket layer: used by many applications
  - Low level interface: exposes address class, options, ..
  - Compatibility library, raising level of abstraction
- Others: trust management, bootstrapping a network, billing, ..

Routing Evolvability is Hard

- Need routing protocol per XID type
  - Different goals, incentives
- Routing protocols are very diverse
  - Different scope, control by different actors
- General methodology not clear

```
Input  Output
Y      N
Route Success?

NID  HID  SID  CID
Next-Dest XID Type Classifier
```
Need to Rethink the Control Plane

• Individual protocols should be evolvable
  – Much harder than data plane – “intent” of actors is more complex and harder to express
  • A bit easier for applications, e.g., video
  – Ongoing research focusing on BGP style protocols
  – Requirements depend on the goals
• Must be easy to add new protocols
  – Needed as we add new XID types
  – This should not be super expensive
  – Not clear what a general methodology is

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Headers – How Hard Can it Be?

• XIA header modeled after IP header
  – Source and destination address (DAGs include both address and SID of the socket)
  – Version, TTL, length
• Source addresses used for accountability
  – Role can be separate from return address
  – A bit tricky fallbacks – need more experience
• Need indication whether content is cacheable
  – should be separate from source address

DAGs – Manageable but a Bit Messy

• Constructing good DAGs is a bit tricky
  – Should not be left to users or applications
• General idea: destinations (services) advertise their DAG but senders can modify it
  – E.g., insert in-path services, policy issues, ..
  – Should be done by a package
• Client node get DAG from network
  – Customization done using place holder XIDs
• Policy compliance checking easy for simple DAGs
  – Limited experience with complex DAGs
What Does This mean?

- SID<sub>m</sub> is visible (non-transparent) middlebox
  - Trusted by source since it inserted the SID in DAG
- Can be used for any traditional middlebox
- Also used for custom forwarding or address translation services
  - Rendez-vous mobility service, inserting Scion ID
  - More general: delegating address creation

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Porting Applications is a Pain

- And it is mostly not research!
- XIA xsocket = ~IP sockets + get and put chunk
- Solution: translates IP socket calls automatically and add CID calls manually
  - The latter is research!
- Solution is based on a wrapper library
  - (IP, socket) -> XIA DAG
  - Kind of like a weird NAT
- Discussion? Experiences

Protocol Stack Rethinking

- Some XIDs push application layer concepts to the network layer
  - Content, services, “discovery”, ...
  - Jumps over the transport layer
- These concepts are application independent
  - But in practice applications need application specific meta data, e.g., HTTP vs GetChunk CID
- General question: difference between an XID and a protocol – how much header needed?
Not Just a Technical Artifact

- Network technology is used in a variety of contexts with different constraints
  - Flexibility helps diverse deployments and runtime tussles
- Economic incentives angle helps guide research
  - Should not block promising research directions
  - Help understand applicability, scope, ...
- Privacy is complex issue
  - No size fits all
  - Refined network support potentially complicates interface to user

Random Thoughts

- Publishing architecture papers
  - Students expressed concern in Boston
  - Has gotten better, but still is an issue
  - Generally easier to sell papers that are mostly architecture agnostic – use IP and FIA as examples
- Use cases involve a lot of infrastructure
  - Web + video platforms (video), hardware + operational issues (vehicular)
  - We really underestimated this
  - Silver lining: prototype is getting a lot better
More Topics (short)

• Different XID types need different ctl protocols – reflects semantics – not just BGP++
  – Several of these protocols look, well, quite different – any general concepts?
• Services allow visible in-path services, specialized forwarding semantics (based on header, ...)
  – Changes architecture