XIA: An Architecture for a Trustworthy and Evolvable Internet

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Outline

• The eXpressive Internet Architecture – a proposal
  – Example and concepts
  – Research thrusts
• Tapa: supporting mobile users
  – Concepts
  – Applications
  – Tapa as an XIA transport

Today’s Internet

- Client retrieves document from a specific web server
  - But client mostly cares about correctness of content, timeliness
  - Specific server, file name, etc. are not of interest
- Transfer is between wrong principals
  - What if the server fails?
  - Optimizing transfer using local caches is hard
    • Need to use application-specific overlay or transparent proxy – bad!

eXpressive Internet Architecture

- Client expresses communication intent for content explicitly
  - Network uses content identifier to retrieve content from appropriate location
- How does client know the content is correct?
  - Intrinsic security! Verify content using self-certifying id:
    hash(content) = content id
- How does source know it is talking to the right client?
  - Intrinsic security! Self-certifying host identifiers
A Bit More Detail ...

P1: Evolvable Set of Principals
- Identifying the intended communicating entities reduces complexity and overhead
  - No need to force all communication at a lower level (hosts), as in today’s Internet
- Allows the network to evolve

What About Dynamic Content?

P2: Security as Intrinsic as Possible
- Security properties are a direct result of the design of the system
  - Do not rely on correctness of external configurations, actions, data bases
  - Malicious actions can be easily identified
Other XIA Principles

• Narrow waist for trust management
  – Ensure that the inputs to the intrinsically secure system match the trust assumptions and intensions of the user
  – Narrow waist allows leveraging diverse mechanisms for trust management: CAs, reputation, personal, ...
• Narrow waist for all principals
  – Defines the API between the principals and the network protocol mechanisms
• All other network functions are explicit services
  – XIA provides a principal type for services (visible)
  – Keeps the architecture simple and easy to reason about

What Applications Does XIA Support?

• Since XIA supports host-based communication, today’s applications continue to work
  – Will benefit from the intrinsic security properties
• New applications can express the right principal
  – Can also specify other principals (host based) as fallbacks
  – Content-centric applications
  – Explicit reliance on network services
  – Mobile users
  – As yet unknown usage models

XIA: eXpressive Internet Architecture

• Each communication operation expresses the intent of the operation
  – Also: explicit trust management, APIs among actors
• XIA is a single inter-network in which all principals are connected
  – Not a collection of architectures implemented through, e.g., virtualization or overlays
  – Not based on a “preferred” principal (host or content), that has to support all communication

What Do We Mean by Evolvability?

• Narrow waist of the Internet has allowed the network to evolve significantly
• But need to evolve the waist as well!
  – Can make the waist smarter

XIA adds evolvability at the waist:
- Applications
- Evolving set of principals
- Link technologies
- Link technologies

IP: Evolvability of:
- Applications
- Link technologies
It Is Not Just About Architecture!

- End-to-end transport over heterogeneous networks
  - TCP works well over wired segments
  - How to better support wireless mobile users, insertion of services, vehicular, DTNs, ...
- Trustworthy network operations
  - Improve “security” broadly defined by leveraging the intrinsic security properties of XIA
  - Focus on systematic approaches to trust management and availability

What About the Real World?

- Relationship among providers
  - Impact of multiple principals, new routing paradigms, etc. on economic incentives
  - Net neutrality, audit trails for billing purposes, ...
- Interfaces for applications and users
  - Why would users trust data that can come from “anywhere”; why would they make data available?
  - Focus is on an audit trail capability both at the network and user level
  - User studies to evaluate impact on user’s attitude

XIA Components and Interactions

Outline

- Background
- The eXpressive Internet Architecture – a proposal
  - Example and concepts
  - Research thrusts
- XIA building blocks:
  - AIP
  - Tapa
Developing XIA v0.1

• Principles do not make a network!
• Meet the core XIA team:
  - Fahad Dogar
  - Dongsu Han
  - Hyeontaek Lim
  - Ashok Anand
  - Aahok Anand
• Next: quick look at multiple principals, intrinsic security, and evolvability

Multiple Principal Types

• Hosts XIDs support host-based communication similar to IP – who?
• Service XIDs allow the network to route to possibly replicated services – what does it do?
  – LAN services access, WAN replication, ...
• Content XIDs allow network to retrieve content from “anywhere” – what is it?
  – Opportunistic caches, CDNs, ...
• Autonomous domains allow scoping, hierarchy
• What are conditions for adding principal types?

Intrinsic Security in XIA

• XIA uses self-certifying identifiers that guarantee security properties for communication operation
  – Host ID is a hash of its public key – accountability (AIP)
  – Content ID is a hash of the content – correctness
  – Does not rely on external configurations
• Intrinsic security is specific to the principal type
• Example: retrieve content using ...
  – Content XID: content is correct
  – Service XID: the right service provided content
  – Host XID: content was delivered from right host
Example of Secure Mobile Service Access

Evolvability

• Introduction of a new principal type will be incremental – no “flag day”!
  – Not all routers and ISPs will provide support from day one
  – No universal connectivity
  – Some ISPs may never support certain principal types

• Solution is to provide an intent and fallback address
  – Intent address allows in-network optimizations based on user intent
  – Fallback address is guaranteed to be reachable

Generalizing Evolvable Address Format

• Use a directed acyclic graph to represent address
  – Router traverses the DAG
  – Priority among edges

• DAG format supports many addressing styles
  – Shortcut routing, binding, source routing, infrastructure evolution, ..
  – Common case: small dag, most routers look at one XID

Prototype Implementation

• Click implementation of XIA router
• Python API for sending/receiving packets
• Implemented a web service using XIA
• User-level version runs over ProtoGeni