XIA: An Architecture for a Trustworthy and Evolvable Future Internet

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Outline

- Vision
- Getting real
- The real world

2

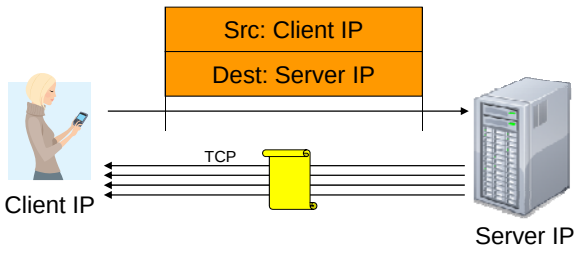
Vision

We envision a future Internet that:

- Is trustworthy
  - Security broadly defined is the biggest challenge
- Supports long-term evolution of usage models
  - Including host-host, content retrieval, services, …
- Supports long term technology evolution
  - Not just for link technologies, but also for storage and computing capabilities in the network and end-points
- Allows all actors to operate effectively
  - Despite differences in roles, goals and incentives

3

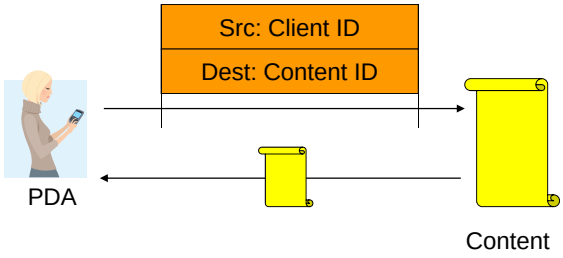
Today's Internet



- 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!

4

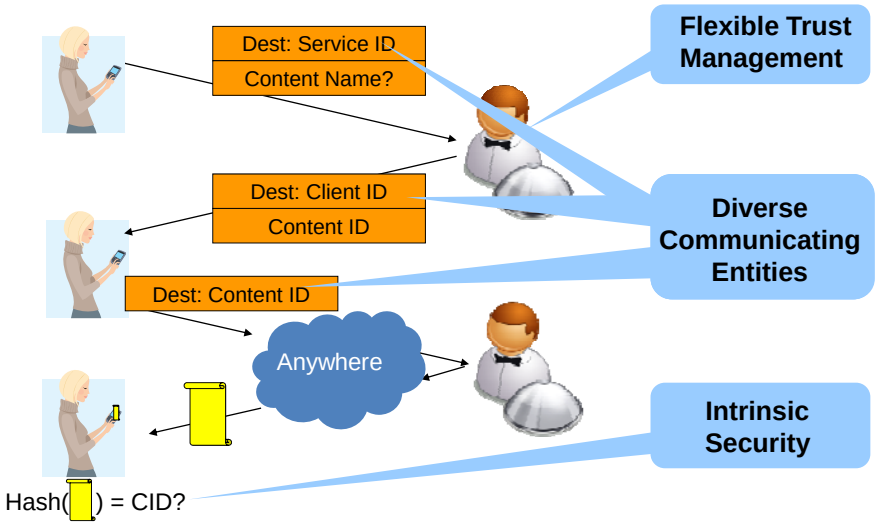
eXpressive Internet Architecture



- 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

5

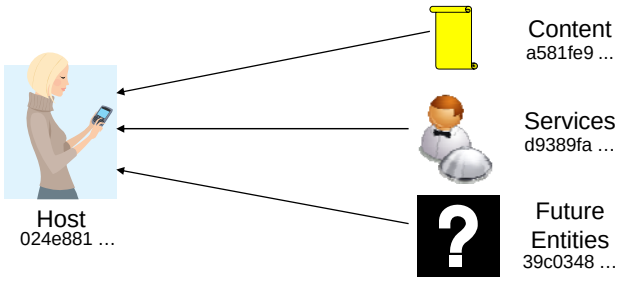
A Bit More Detail …



6

P1: Evolvable Set of Principals

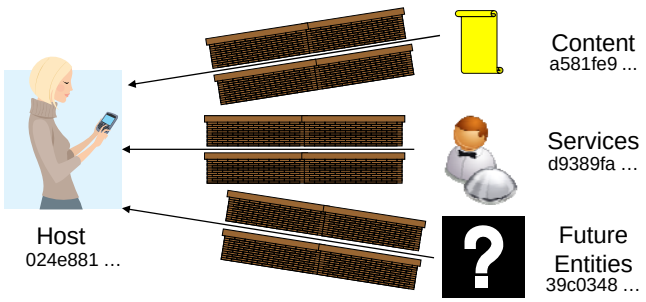
- Identifying the intended communicating entities reduces complexity and overhead
  - No need to force all communication at a lower level (hosts), as in today's Internet
- Allows the network to *evolve*



7

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



8

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

9

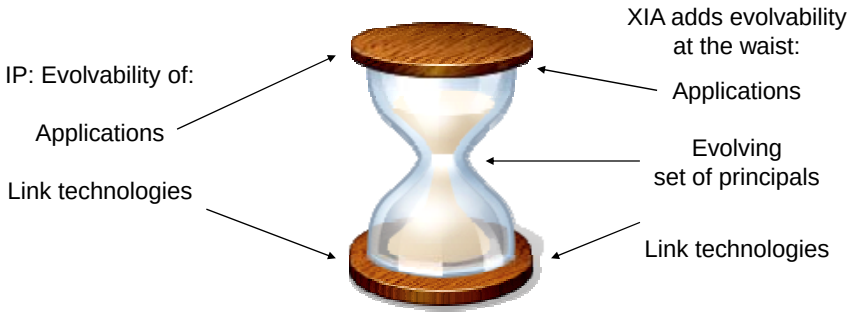
XIA: eXpressive Internet Architecture

- 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

10

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



11

Developing XIA v0.1

- Principles do not make a network!
- Meet the core XIA team:

Five happy professors cheering:
John Byers, Aditya Akella, Dave Anderson, Srini Seshan, Peter Steenkiste


Fahad Dogar


Dongsu Han


Hyeontaek Lim


Ashok Anand


Michel Machadoy


Boyan Li


Wenfei Wu

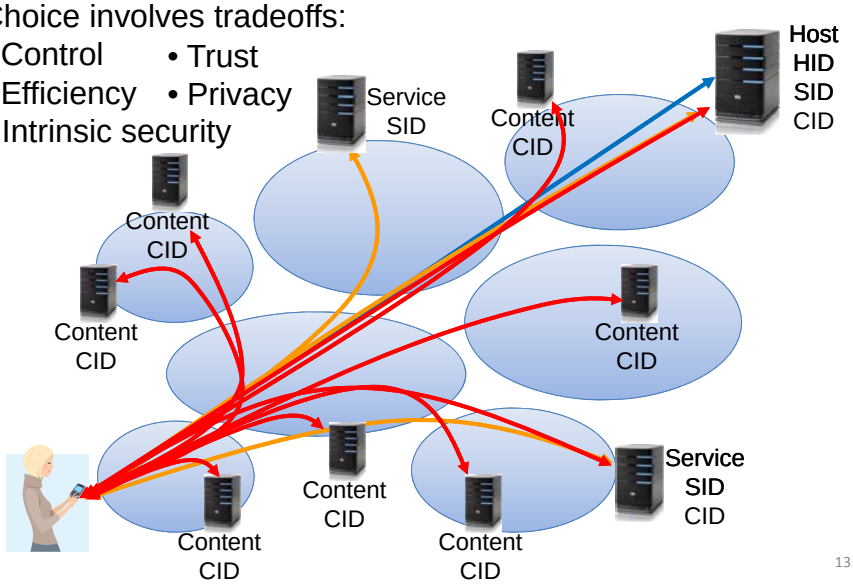
- Next: quick look at multiple principals, intrinsic security, and evolvability

12

Multiple Principal Types

Choice involves tradeoffs:

- Control
- Trust
- Efficiency
- Privacy
- Intrinsic security



13

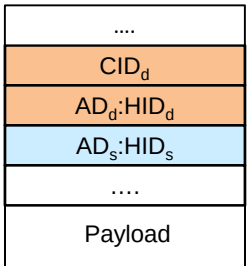
Intrinsic Security in XIA

- 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
  - Important – guarantees depend on 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

14

Evolvability

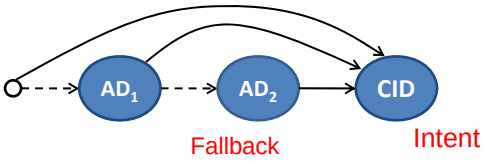
- Introduction of a new principal type will be incremental – no "flag day"!
  - Not all routers and ISPs will provide support from day one
  - No universal connectivity
  - Some ISPs may never support certain principal types
- Solution is to provide an *intent* and *fallback* address
  - Intent address allows in-network optimizations based on user intent
  - Fallback address is guaranteed to be reachable



15

Generalizing Evolvable Address Format

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

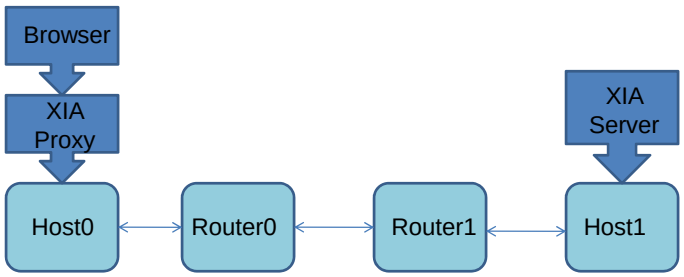


- DAG format supports many addressing styles
  - Shortcut routing, binding, source routing, infrastructure evolution, ..
- Packet processing combines basic and principal specific processing

16

Prototype Implementation

- Click implementation of XIA router
- Python API for sending/receiving packets
- Implemented a web service using XIA
- Ran simple tests over ProtoGeni



It Is Not Just About Architecture!

- End-to-end transport over heterogeneous networks and for mulitple principals
  - Error control, congestion control, …
  - 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 availability and systematic approaches to trust management

18

What About the Real World?

- Policy and economic viability
  - Impact of multiple principals on economic incentives
  - Net neutrality, audit trails for billing purposes, …
- Interfaces for applications and users
  - Value of network depends on whether users are willing to use all its capabilities - User trust is key
  - User studies to evaluate impact on user's attitude
- Rich interactions with core network, security

19

Conclusion

- XIA supports evolution, expressiveness, and trustworthy operation.
  - Multiple principal types and intrinsic security
- But research has just started!
  - Protocols that take advantage of in-network caches and services
  - Trustworthy protocols that fully utilizes intrinsic security of XIA
- More information on

  http://www.cs.cmu.edu/~xia