XIA and the DARPA Scenario

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Public Internet versus Scenario (Broadly Interpreted)

- ≈ Rapidly evolving technologies: communications, storage, computing, …
  - ≠ More heterogeneity in scenario, including legacy
  - – Suggests some need for evolvability
- ≈ Relatively stable core with mobile edge
  - ≠ More radical mobility, dynamic topology in scenario
  - – Need for proactive topology management
- ≠ Trust management and security requirements
- ≠ All-to-all versus restricted communication
- ≠ Richer in-network functionality, e.g., DTN, multicast

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Outline

- XIA overview
  - Typed identifiers
  - Flexible addressing: fallbacks and scoping
  - Intrinsic security
- Applying XIA to the scenario

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1. Multiple Principal Types

- Associated with different *forwarding semantics*
  - Support heterogeneity in usage & deployment models
- Identifiers for hosts, content, networks, services, …
  - Supports push, pull, …
  - Content/service centric support
- XIDs need control plane consistent with semantics
- Set of principal types can evolve over time
  - Dynamic content, pub-sub, …, DTN, multicast, …

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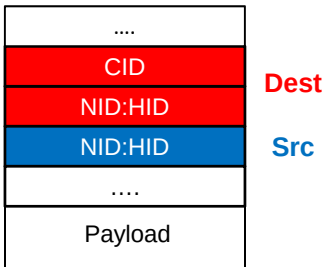
Supporting Evolvability

- Introduction of a new principal type will be incremental – no "flag day"!
  - Not all routers and ISPs will provide support from day one
- Solution is to provide an *intent* and *fallback* address
  - Intent allows the network to optimize based on user intent
  - Fallback must be guaranteed to be reachable and is used if the intent "fails"

– Also enables heterogeneity and customization



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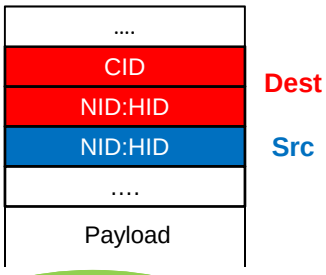
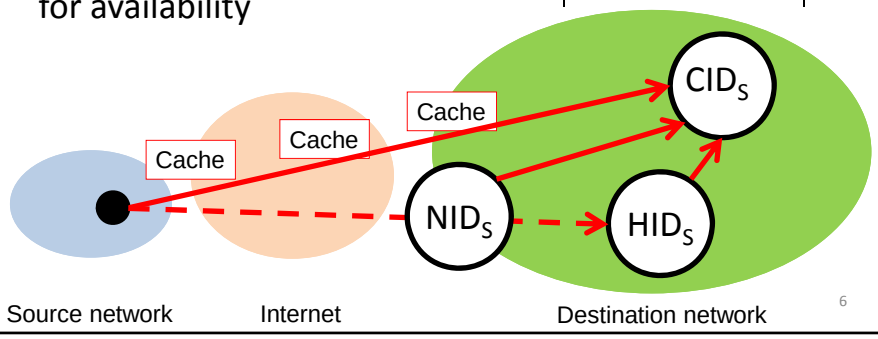
2. Flexible Addressing: DAGs

- Combining fallbacks and scoping offers flexibility for network in completing request
- Supports network heterogeneity and in-network error recovery for availability





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3. 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
  - For example, to DoD trust management systems
- Useful for bootstrapping e-e security solutions
  - Address spoofing, DoS defense, …
  - Also useful for bootstrapping networks and operation in disconnected and partitioned networks

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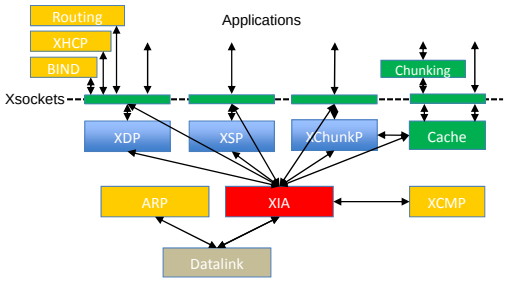
Open Source XIA Release

https://github.com/xia-project/



- XIA prototype released in 2012
- Used for evaluation, applications, services
- New functionality is being added regularly

- Full XIA protocol stack - support for NIDs, HIDs, SIDs, and CIDs
- Basic inter and intra domain routing protocols for the XIDs
- Support services and utilities, including name service; caching; equivalents for XHCP, ARP, ICMP; wireshark; socket remapping
- Vehicular and video distribution use cases push development

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Outline

- XIA overview
- Applying XIA to the scenario
  - Requirements
  - Discussion focuses on
    - Novel security concepts
    - Availability
    - Topology control

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Key Requirements Scenario

1. Existing and novel security constructs
2. Topology control; DTN and data mules
3. Availability
4. Dynamic storage and computation
5. Bootstrapping networks
6. Heterogeneous links and QoS

Assumption for now: XIA only network using diverse technologies

Hybrid network layers will be discussed later

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Authentication and Accountability

- XIDs are securely bound to an identity based on XID type
  - Service, host, content, etc.
  - Can be used to verify authenticity of the end-point
  - Properties target public Internet
- Roles, organizations, area of operation, etc. can either be:
  1. Incorporated into new XID types
  2. or looked up externally with other secure XIDs

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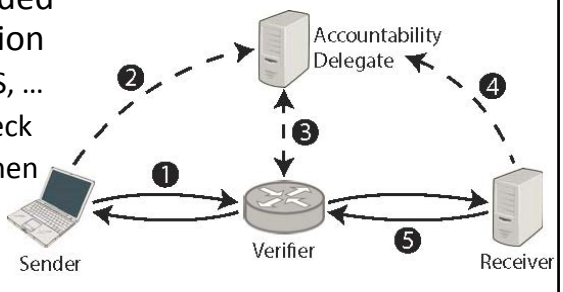
A Closer Look at Accountability

- Intrinsic security can be used to prevent spoofing
  - Routers can ask sender to sign a challenge with the private key matching public key of the HID in the source address
  - Can be viewed as authorization for basic network service
- Idea could be expanded for richer authorization
  - Network access, QoS, …
  - Local or external check
  - Non-repudiation, when disconnected and breaking the rules is necessary



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Disconnected Operation

Most Basic Address

Smart In-Path Service

- XIDs are not effected by changes in the network configuration
  - No reconfiguration of end-points required
  - Easier to manage address spaces
- As networks split and merge, or nodes get disconnected, their identity remains the same
  - Can use HID to verify that one is communicating with the same entity w/o third party
  - Change NID to locate it in a network
  - Smart in-network services can help manage

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Topology Control

- Multiple organizations are represented by multiple "domains" represented by NIDs
  - Managed independently
  - Can be very heterogeneous
- Topics related to communication topologies
  - Controlling access to links and networks (requirement 1)
  - Asynchronous communication
  - Controlling paths

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Intermittent Connectivity, DTN and Data Mules

- Caches can be used as a building block for asynchronous end-end communication
- Caches manage content (chunks) using CIDs
  - Chunks can be pushed to a cache (authorization)
  - Chunks can be discovered/fetched using different XID thypes, e.g., CIDs, "request" IDs (names), …
- Mule: push chunks to a rendez-vous cache where they are fetched by a UAV
- DTN: chunks "hop" from cache to cache as "links" become available

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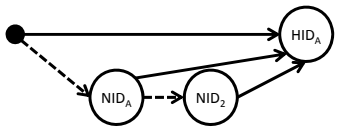
Source Routing



- Flexible DAG address format allows source routing to a destination
  - Specify full or partial path
  - Use in Internet raises policy and economic issues
- Can be used to reach destination
  - Before routing has stabilized
  - In the presence of failures
- Anything else?

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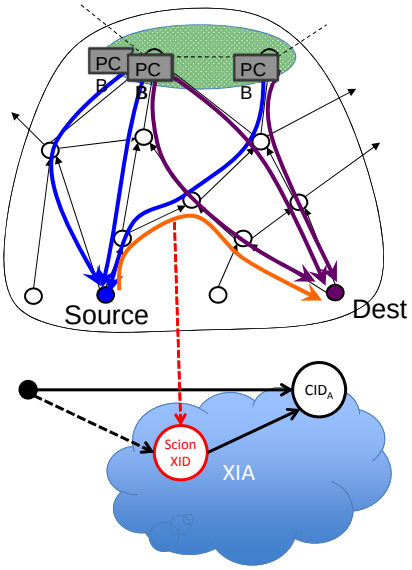
Path-based Forwarding



- XIA supports forwarding based on a cryptographically enforced Scion path
  - Path defined as a sequence of cryptographic MACs
  - Represented by a "Scion ID"
- Receiver can verify path was followed
- Variety of mechanisms for picking paths
  - Alternate paths can have different properties

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Redundancy

- Different XID types can provide alternate means of completing the communication
  - E.g., reach content using CID, SID, or HID
  - Can use completely independent forwarding and control plane mechanisms
- Some XID types inherently support replications
  - Caching of data inside network
  - Replicated services

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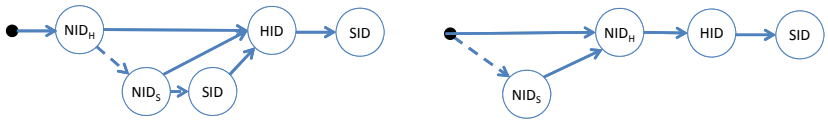
Flexible Addressing

- Fallbacks support in-network error recovery in the presence of failures
  - Alternatives tend to take time:
  - Waiting for new routes to stability
  - Relying on retransmission from sender
- Fallbacks can use alternate paths or services
  - Paths can include loose source routing



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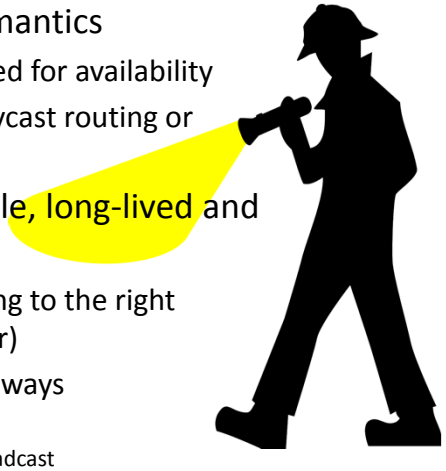
Discovery of Dynamic Storage and Computing

- CIDs (storage) and SIDs (computing) provide discovery with anycast semantics
  - Destination can be replicated for availability
  - Reach destination using anycast routing or broadcast
- HIDs/CIDs/SIDs are portable, long-lived and secure
  - You can verify you are talking to the right endpoints (discussed earlier)
  - Can be distributed in many ways
    - Out of band or pre-deployment
    - Through registry service, or broadcast



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Bootstrapping Networks

- Bootstrapping networks requires establishing trust; discovering nodes, services, storage; and authorization for access to those services/storage
- Initially, trusted can be established based on pregenerated XIDs (hosts, SIDs, CIDs, ..) and authorization can be based on preloaded policies
- Discover mechanisms discussed earlier
- Once more infrastructure is in place, trusted name services, resource directories (time stamp, …) can be deployed for more scalable, efficient and secure operations.

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Connecting Networks

- Connecting networks involves
  - Trust management (credentials; NIDs, names, …), exchange service capabilities, agreement on sharing/using services, configuration, …
- Example is “network joining” protocol being developed for vehicular networking use case
  - Offers flexibility for how each step is performed, depending on the configuration of the parties
  - Tries to optimize latency of connect time
- Requirements are likely to be radically different here

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Heterogeneous Links

- Network management control typically uses a abstractions of actual links
  - Basic properties in public Internet: bandwidth, …
  - Can be more sophisticated, e.g., for wireless: range, bit rate, dynamics, …
- Link abstraction that is shared by end-points/ users and the network
  - Users can specify their requirements
  - Network can advertise capabilities, or configure link based on user requirements

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Providing QoS

- Real-time, low latency, priorities, …
- Mechanisms for QoS are well understood
- Policies are specific to the context
  - Agreement on end-end policies in multi-organization network is a hard problem
- Authorization is a key requirement
  - Senders cannot mark all packet as “real-time”
  - Can leverage mechanisms under requirement 1

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Mixing XIA and IP

- We have experience with 3 “types” of mixes:
  - Running protocol over the networks in parallel
  - One protocol runs as overlay over other (static)
  - XIA network clusters separated by the public Internet (uses an 4ID identifier)
  - IP applications communicating over XIA (~NAT)
- More general combinations would probably use a combination of these concepts
  - Quantify loss of benefits

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Conclusion

XIA Concepts

1. Multiple identifiers type
   - Evolvability
   - Accommodates heterogeneity
2. Fallbacks, flexible address
   - Evolvability, heterogeneity
   - Availability
3. Cryptographic identifiers
   - Built-in authentication
   - Simplify configuration
   - Mobility, disconnected, …

Scenario Requirements

1. Existing and novel security constructs
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