Transactions in ICN

Dirk KUTSCHER

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ICNRG @ IETF-119

香港科技大学(广州)
THE HONG KONG
UNIVERSITY OF SCIENCE AND
TECHNOLOGY (GUANGZHOU)

ICN and Distributed Computing

- Group of nodes evolving a common state
- State: could be seen as shared namespace and its Named Data Object (NDO) hierarchy
- NDOs immutable and 'uniquely' named
- State evolution through NDO publication events
- Protocols such as PSync, SVS.

Transactions – ACID properties

- **Atomicity: operations as single entity**
- **Consistency: maintaining consistent state before and after transactions – easier in client-server settings...**
- **Isolation from other transactions**
- **Durability: transactions make persistent changes to data**

Typically easier to achieve in client-server settings

Different Ways to Realize Transactions

1. ICN as a network layer

- Client-server communication between two nodes
- Implement transaction semantics on top of an ICN messaging service

2. Recording state changes in shared data structures

- Shared namespace, potentially functioning as a transaction ledger
- Still need to think about atomicity etc.

1. Transactions as Messaging over ICN Network

- **Client-server communication between two nodes**
- **Implement transaction semantics on top of an ICN messaging service**
- **Different approaches**
  - A: **Traditional layering**: Using NDN-like systems as a messaging layer
    - Assign prefixes to client & servers
    - Send messages back and forth, and implement reliability and transactions semantics on top
  - B: **ICN-native communication**: Use Interest-Data as request-response abstraction for transactions
    - Mapping transaction communication and state evolution more directly to ICN, e.g., Interest-Data in NDN
    - Collapsing traditional network, transport, application layer functions

Today

1. **B: ICN-native communication: Use Interest-Data as request-response abstraction for transactions**
   - Based on RICE and Reflexive Forwarding
2. **Recording state changes in shared data structures**
   - Based on manifests

Secure Web Objects and Transactions

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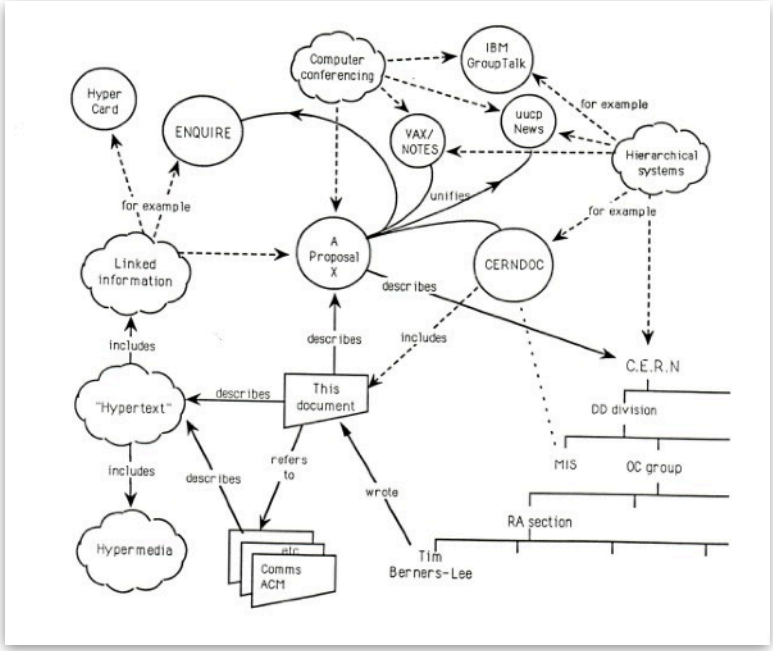
Original Web Idea

- **Hypermedia system with document composability and application interoperability**
  - Characterized as an Information Management approach
  - Different types of link semantic
  - Different types of applications (not only static object access)

- **Universal Naming Concept (URIs)**
  - Independent of server locations/addresses



Web Reality

- **E-commerce-driven security architecture**
  - TLS-based server authentication for bootstrapping secure communication between clients and servers
  - Names (DNS) for servers mostly

- **Elaborate distribution of app logic, rendering, UX**
  - Server- and client-side frameworks: React, Vue, Node.js etc.
  - Virtual secure pipe between browsers and servers – "single server applications"

Data-Oriented Web

Information systems start small and grow. They also start isolated and then merge. A new system must allow existing systems to be linked together without requiring any central control or coordination. – Tim Berners-Lee

- **Enable Web applications to create and exchange Web objects**
  - Accessed by URI-like names
  - Without relying on the communication channel for security
- **(Re-)enable an array of different interaction styles,**
  - Individual Web object access across applications
  - Scalable multi-destination distribution
- **Secure web objects (SWOs)**
  - Application-data units – usual ICN properties
  - Trust beyond Web-PKI – ICN-intrinsic certs and key access
  - Amenable to both infrastructure-connected as well as local information access: local-first communication
- **SWOs beyond Named Data Objects**
  - Meta data concept to support computing on and on-demand transformation of objects
  - Provenance
  - Effective group access control and key distribution

ICN Components – What do We Need?

- **WebRTC-style interactive media**
  - Protocol-wise, we know how to do this
  - Opportunity in creating Zoom-scale conferencing systems with in-network mixers and transcoders
  - Unifying scalable media distribution and low-latency streaming / interactive communication à la Media-Over-QUIC (MOQ)
- **Linking and aggregation**
  - File-like ICN Collections (FLIC) – be great to have one way of doing this and usable implementations
  - Collections for dynamic content: more work to do
- **Loosely-coupled coordination / consensus**
  - Sync – ready for web-scale deployment?
  - Higher-layer consensus: mapping app semantics to eventual consistency service: CRDTs – but have to do better than just layering CRDT libraries on top of Sync
- **Transactions**
  - Not everything is about accessing information objects
  - Robust client/server state evolution still needed: "online banking" use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ROBUST: A Reliable and Flexible Media Transport for Real-Time Services

Giovanna Carofiglio, Giulio Grassi, Luca Muscariello, *Senior Member, IEEE*, Michele Papalini, and Jacques Samain


File-Like ICN Collections (FLIC)

draft-irtf-icnrg-flic-05

IETF 118, Prague

Marc Mosko

SRI/PARC

Dave Oran

Network Systems Research & Design

Transactions

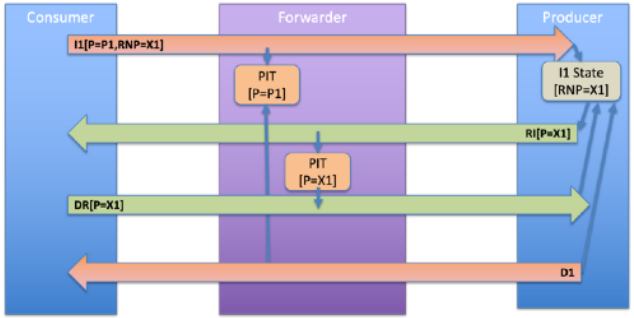
Statement: RESTful Information-Centric Networking

Dirk Kutscher
Hong Kong University of Science and Technology
Guangzhou, Guangdong, China
dku@ust.hk

David Oran
Network Systems Research & Design
Cambridge, MA, USA
daveoran@orandom.net

- **Robust request-response scheme in ICN**
  - Interest/Data not enough
- **Secure session establishment and state evolution**
  - Security context between client and server
  - Authenticated clients
  - Session concept for a series of transactions
- **Data-oriented instead of connection-oriented**
  - Standard encryption and signing ICN objects
  - Potential sharing of "response objects"
- **Unique potential to do multi-party web interactions more efficiently**
  - Individual sessions – but shared responses

Reflexive Forwarding and RICE
draft-oran-icnrg-reflexive-forwarding

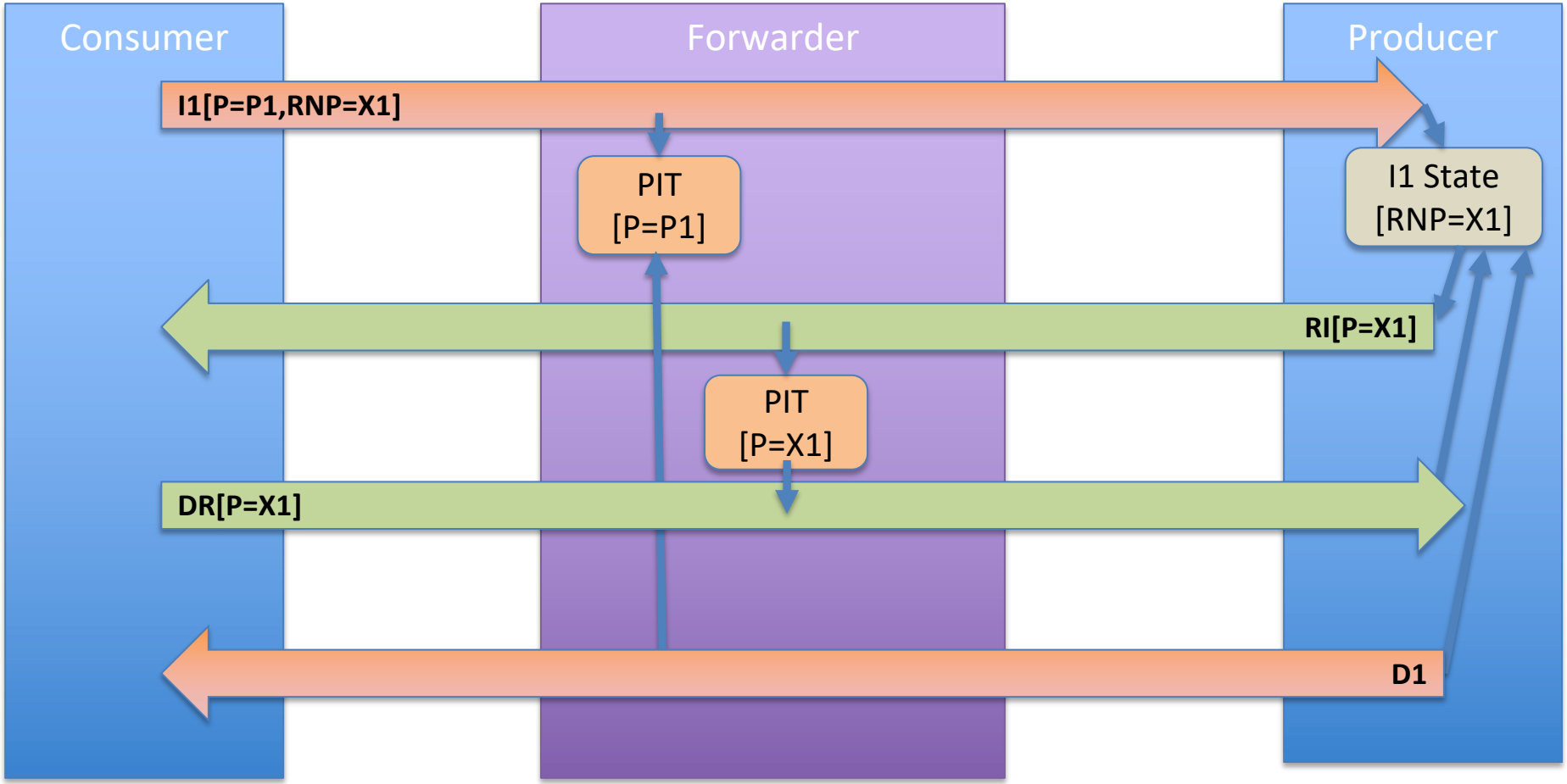


+
CCNx Key Exchange

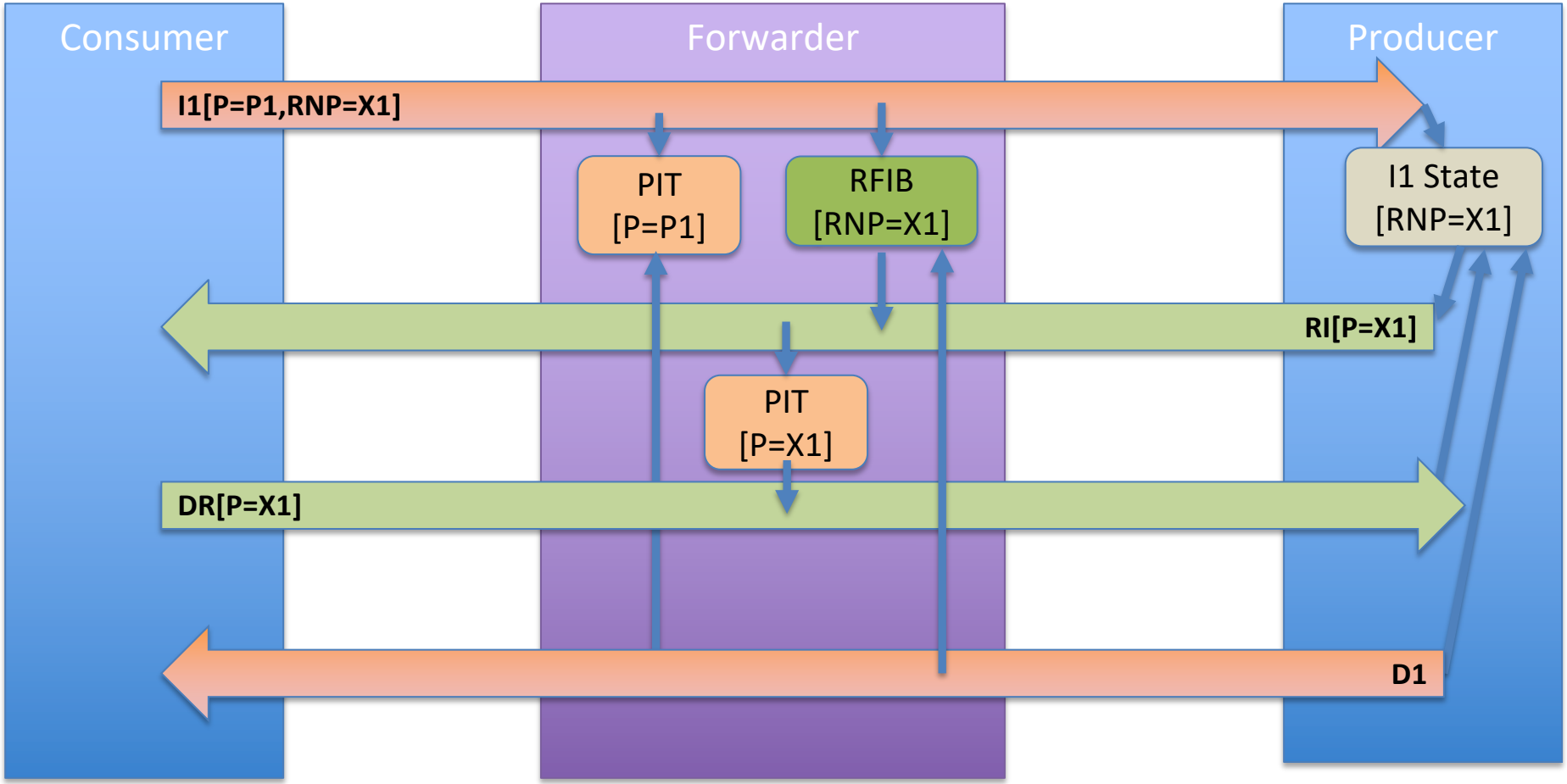
Transactions with Reflexive Forwarding

- **Utilize forwarder state established by Interest sent from consumer to producer**
  - Allow for not just a returning Data message, but a Reflexive Interest to flow from producer to the unique consumer who sent the original Interest
- **Define a scheme for Reflexive Name Prefixes**
  - Can only be seen and understood by already established consumer/producer pairing
  - Do not reveal consumer identity (temporary names within the RI context)
- **Provide forwarder mechanism for routing these back to consumer from producer**
- **Couple state of the original Interest/Data exchange with the reflexive exchange(s)**
  - Ensure state gets mapped correctly by both consumer and producer
  - And unwound properly at forwarders when Data message responding to original Interest is sent back

High-Level Protocol Overview



Previous Approach (version 01)



Conclusion

- **Transactions: how to realize in information-centric systems?**
  - Not about mapping existing protocols, but about actual distributed computing semantics
- **Transactions with ICN-native communication**
  - Hard to provide with with basic Interest/Data
  - Reflexive Forwarding + CCNx Key Exchange + transaction semantics
  - Reflexive Forwarding needs extensions to forwarders
  - What other extensions to current Interest/Data service are needed?
- **Transactions with shared data structures**
  - Next presentation