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Ongoing Research Activities in the GreenICN Project on "Using ICN in Disaster Scenarios"

Related Drafts:
draft-seedorf-icn-disaster-03
draft-seedorf-icn-wot-selfcertifying-01
draft-jiachen-icn-pubsub-01

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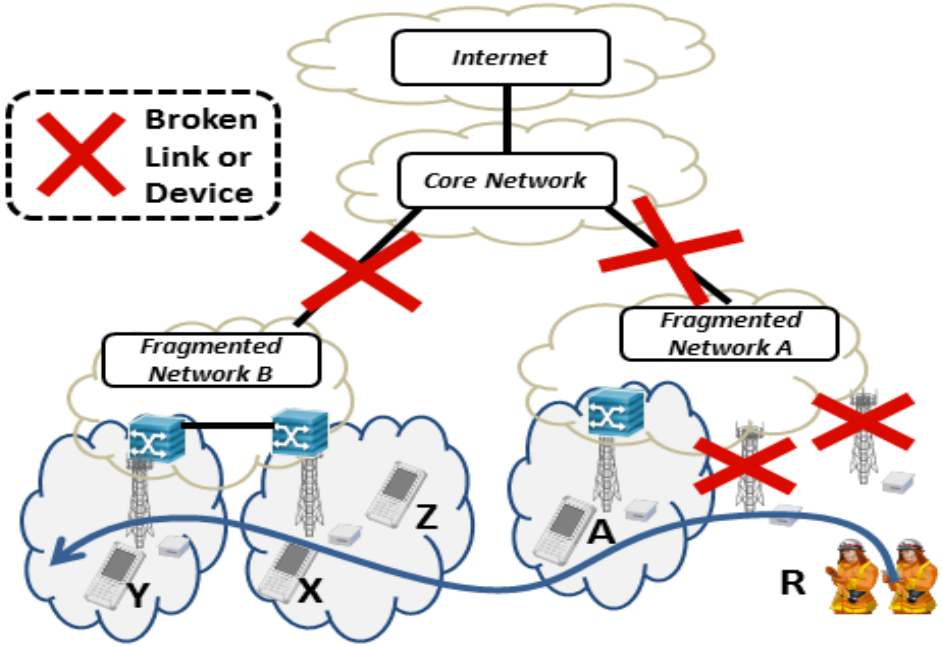
PROBLEM SPACE & RESEARCH CHALLENGES

Scenario and Use Cases

Disaster Scenario

- The aftermath of a disaster, e.g. hurricane, earthquake, tsunami, or a human-generated network breakdown
- E.g. the enormous earthquake which hit Northeastern Japan on March 11, 2011 (causing extensive damages including blackouts, fires, tsunamis and a nuclear crisis)



Key Use Cases (High-Level)

- Authorities would like to inform the citizens of possible shelters, food, or even of impending danger
- Relatives would like to communicate with each other and be informed about their wellbeing
- Affected citizens would like to make enquiries of food distribution centres, shelters or report trapped, missing people to the authorities

Research Gap

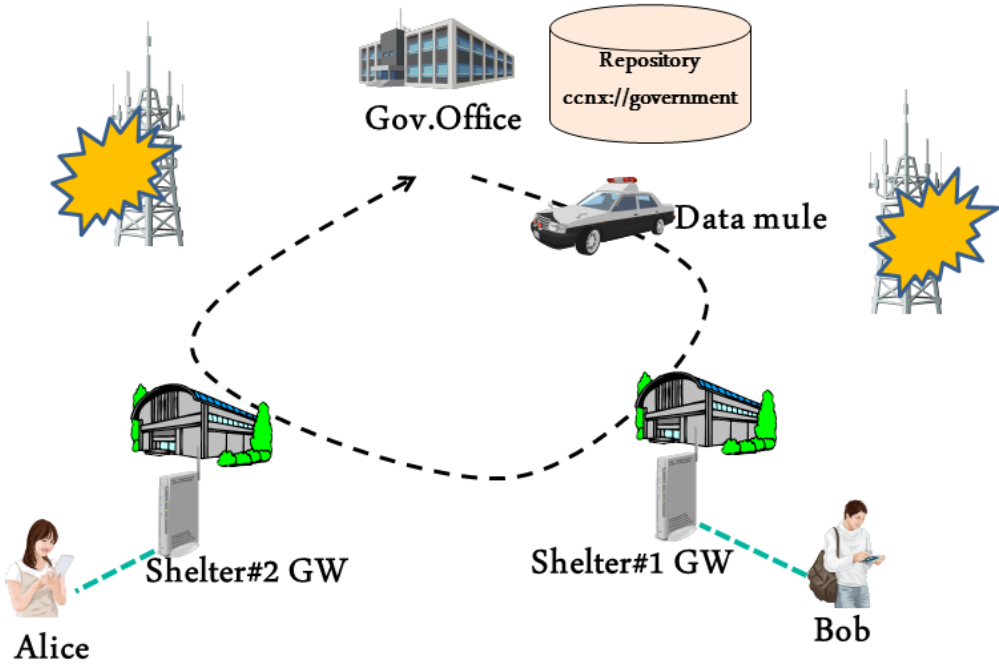
- Quite some work in the DTN community, however most DTN work lacks key features which are needed in the disaster scenarios we consider, such as
  - publish/subscribe (pub/sub) capabilities, caching, multicast delivery, message prioritisation based on content types, …
- Could enhance existing DTN approaches with these features – we argue that ICN makes a better starting point for building a communication architecture that works well before & after a disaster
  - ICN data mules have built-in caches and can thus return content for interests straight on
  - Requests do not necessarily need to be routed to a source (as with existing DTN protocols), instead any data mule or end-user can in principle respond to an interest
  - Built-in multi-cast delivery implies energy-efficient large-scale spreading of important information which is crucial in disaster scenarios
  - Pub/sub extensions for popular ICN implementations exist
  - DTN routing algorithms have been solely designed for particular DTN scenarios; extending ICN approaches for DTN-like scenarios ensures that our solution works in regular (i.e. well-connected) settings just as well (important in reality, where a routing algorithm should work before and after a disaster)

→ Our rationale: start with existing ICN approaches and extend them with the necessary features needed in disaster scenarios

ONGOING RESEARCH AND INITIAL RESULTS

ICN ’Data Mules’

- Mobile entities can act as ICN ’data mules’
  - equipped with storage space, moving around the disaster-stricken area gathering information to be disseminated
  - ICN’s concept of decoupling sender and receiver is very suitable for these ’data mules’
- Approach: Dynamic Name-Based Routing (DSDVN)*
  - A name-based routing protocol for fragmented networks based on the well-known Ad-Hoc routing protocol DSDV
  - Extends DSDV to convey name prefix information in the routing message
  - State of links is set to the Face in CCNx and utilized to control retransmission



ICN Data Mules in a Disaster Scenario

*T. Yagyu and S. Maeda, “Demo Overview: Reliable Contents Retrieval in Fragmented ICNs for Disaster Scenario,” in Proc. of 1st ACM Conference on Information-Centric Networking, ser. ICN, Sep. 2014.

Priority dependent Name-based Replication[1]

Approach: NREP (Name-based Replication)

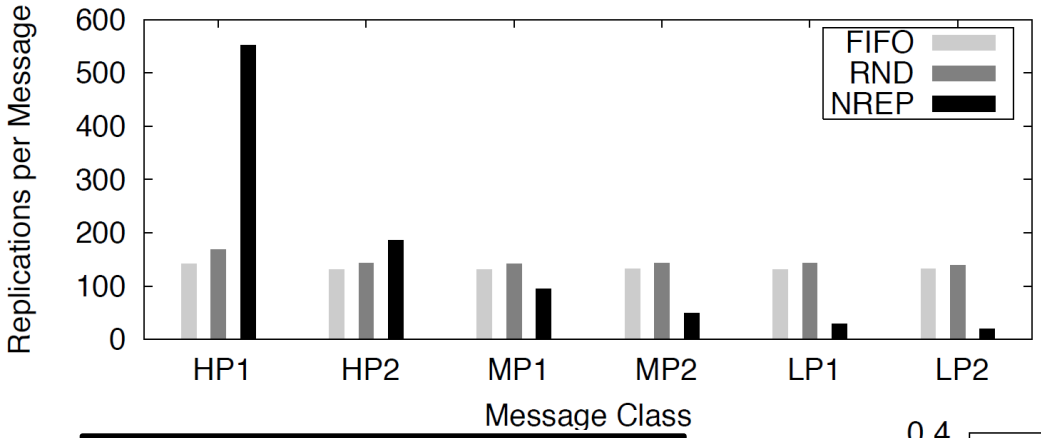
- associate each message generated in a disaster scenario with a *Name + Attributes*
- exploit the information that can be exposed in a content name: *Name-Based Replication*
  - Nodes store-carry-and-forward messages:
    - with specific time and space limits, and
    - with priorities as to what to replicate
  - Time-space limits, as well as priorities are included within the message's name (or attributes field)
- *routing/forwarding decisions are made based on the name*

NREP Design

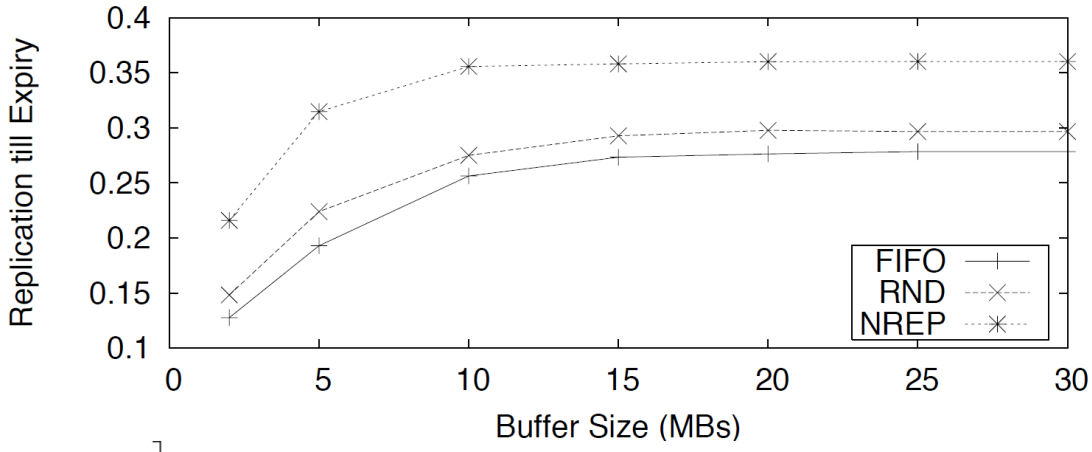
1. *Hierarchical* is working better than flat in this case
   - `Emergency/SOS` or `Warning/Shelter`
   - content can be filtered according to a longest prefix match
   - Namespace has a globally understood prioritisation value
2. The *name* shows the priority
   - `Emergency, Warning, chat`
3. Time and space limits are kept as *attributes*,
   - `boroughX/ttl=2h, radius=Xkm/ttl=Yhours`
4. User-defined priorities kept as attributes too
   - user-perceived importance, e.g., from 1-5 how useful/important was the message

1 - I. Psaras et al., "Name-based replication priorities in disaster cases," in 2nd Workshop on Name Oriented Mobility NOM), 2014.

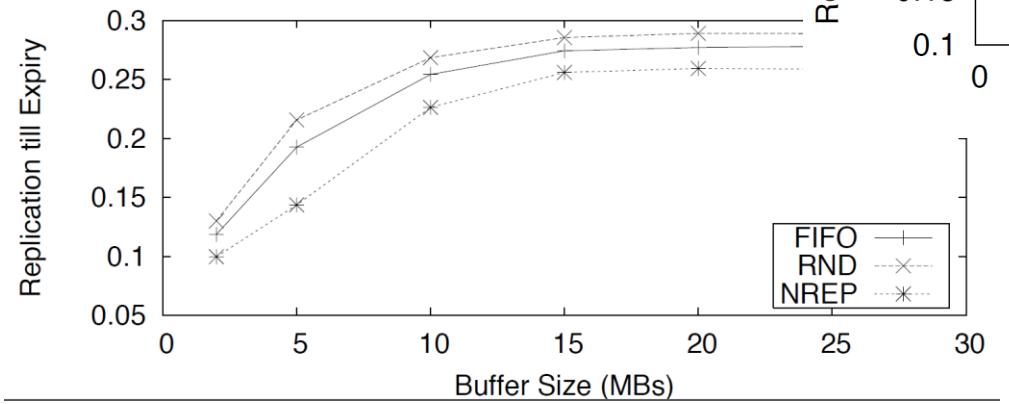
Priority dependent Name-based Replication: Results



Replications Per Message



High Priority Class



Low Priority Class

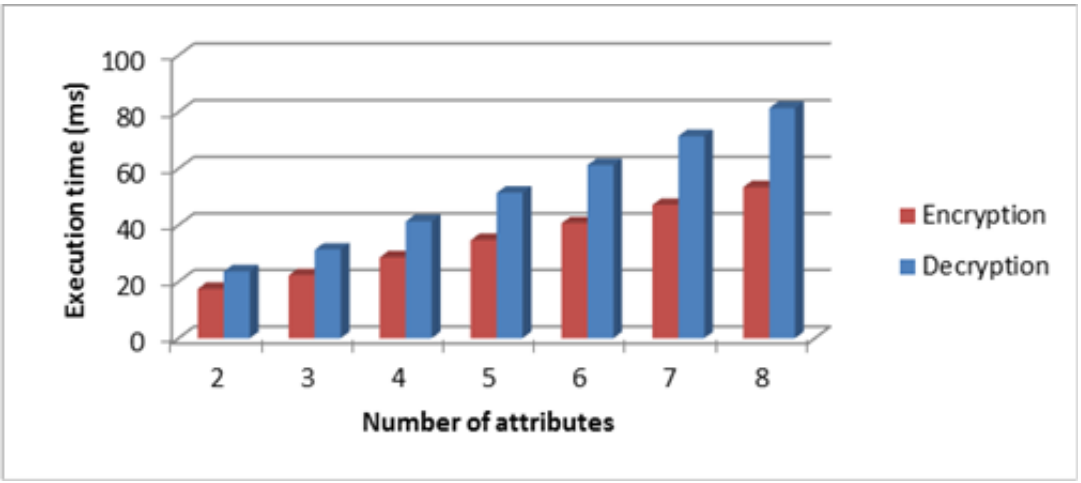
Data-centric Confidentiality and Access Control

- Approach: Use of ’Ciphertext-Policy Attribute Based Encryption’ (CP-ABE)
  - allowing a party to encrypt a content specifying a policy, which consists in a Boolean expression over attributes, that must be satisfied by those who want to decrypt such content
  - Example Policy: allow access only to recipients who fulfill

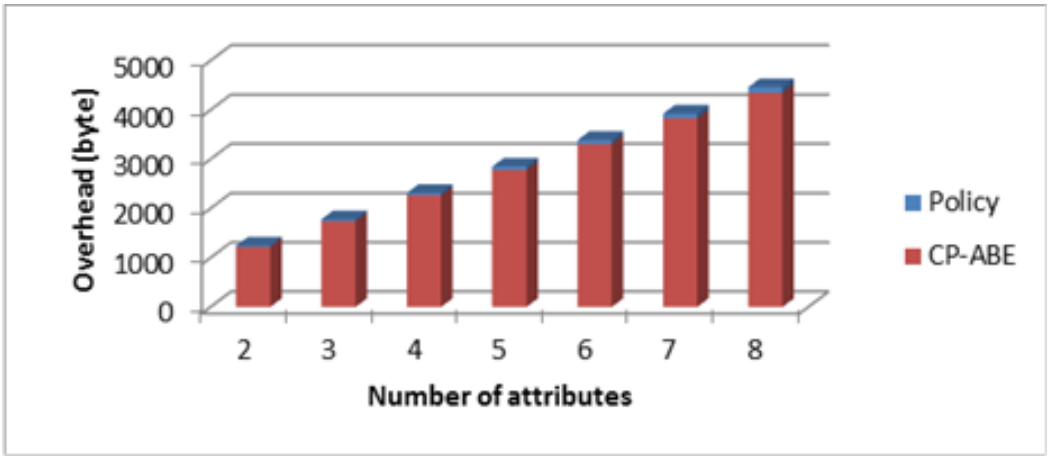
$$\Pi = (\text{job:official} \wedge \text{rank:executive}) \vee (\text{job:emergency} \wedge \text{rank:any})$$

- Our Work / Results*
  - proposed a multi-authority CP-ABE-based security architecture for ICN
  - carried out a performance evaluation, showing that for normal policies (say comprising 2 - 6 attributes) even a Java implementation on a low-end PC requires less than 40ms for encryption (60ms, respectively, for decryption)

Data-centric Confidentiality and Access Control: Results



Execution Time for CP-ABE Encryption and Decryption functions vs number of attributes that form the policy



Overhead introduced in the packet to support the CP-ABE functionalities vs. number of attributes that form the policy

Decentralised Authentication of Messages[1,2,3]

Based on a Web-of-Trust (WoT)

- A so-called *'WoT file'* is being used by terminals
  - can be retrieved from a WoT keyserver before the disaster takes place
  - contains the veried certicate graph for the whole WoT in a compressed, machine-readable format. Terminals thus
- ➢ Terminals have the complete trust relationships within the WoT at their disposal
  - in the from of a 'WoT-graph' stored in a file

Binding between self-certifying ICN names and a Web-of-Trust

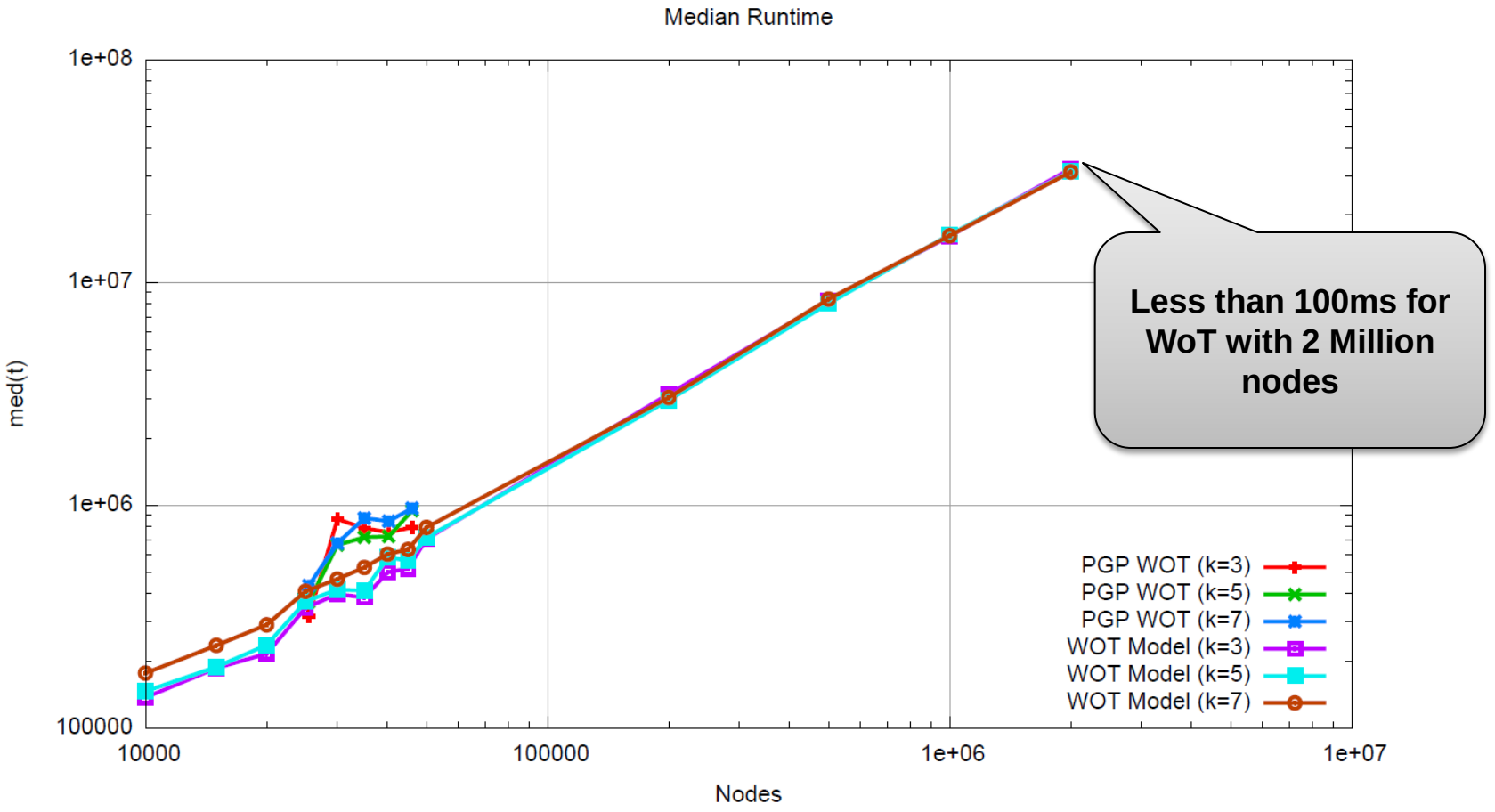
- The WoT key-ID is equivalent to the self-certifying name part used in the ICN naming scheme
- This ties the self-certifying name with the ID of the correct public key in the WoT, and thus transitively with the RWI in the WoT (e.g. email address)

Assessing information received (as a response to a given request for a certain name)

- A double-sided Breadth First Search (`dBFS`) algorithm is executed on the WoT-graph to find certificate chains between the initiator of the request and the publisher of the content
- Depending on a trust metric (see demo for examples) the information received is regarded as trustworthy or not by the initiator of the request
  - trust metric is applied on the result of the `dBFS` algorithm

1 - J. Seedorf, D. Kutscher, and F. Schneider: „Decentralised binding of self-certifying names to real-world identities for assessment of third-party messages in fragmented mobile networks," 2nd Workshop on Name Oriented Mobility (NOM), 2014
2 - J. Seedorf et al.: "Demo overview: Fully decentralised authentication scheme for icn in disaster scenarios (demonstration on mobile terminals)," in 1st ACM Conference on Information-Centric Networking (ICN-2014), 2014.
3 - J. Seedorf: „draft-seedorf-icn-wot-selfcertifying-01"

Decentralised Authentication of Messages: Results



Runtime (in ns) for Decentralised Authentication Approach on Web-of-Trust Graphs of various Sizes (Median)

Energy Efficiency

Considering 3 approaches

- Priority control
  - name-based prioritisation on routing/forwarding
- cell-zooming
  - switching-off some of the Base Stations because switching-off is the only way to reduce power consumed at idle time
- collaborative upload
  - end-devices delegate sending/receiving messages to/from a base station to a representative end-device with radio propagation of better quality
  - complementary to cell zooming

Ongoing Work

- Started with the design of an ICN-based publish/subscribe protocol that incorporates collaborative upload*

* See also: M. Arumaithurai et al.: „draft-jiachen-icn-pubsub-01“

Acknowledgements

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Background: GreenICN Project

- **GreenICN: Architecture and Applications of Green Information Centric Networking**
- Duration: 3 years (1 Apr 2013 – 31 Mar 2016)
- Website: http://www.greenicn.org

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