CCN

CCN Case Studies

Computer Science Laboratory
Networking & Distributed Systems

March 2014

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Project: Custodian-Based Information Sharing

Industry: Consumer Electronics (major Korean conglomerate)

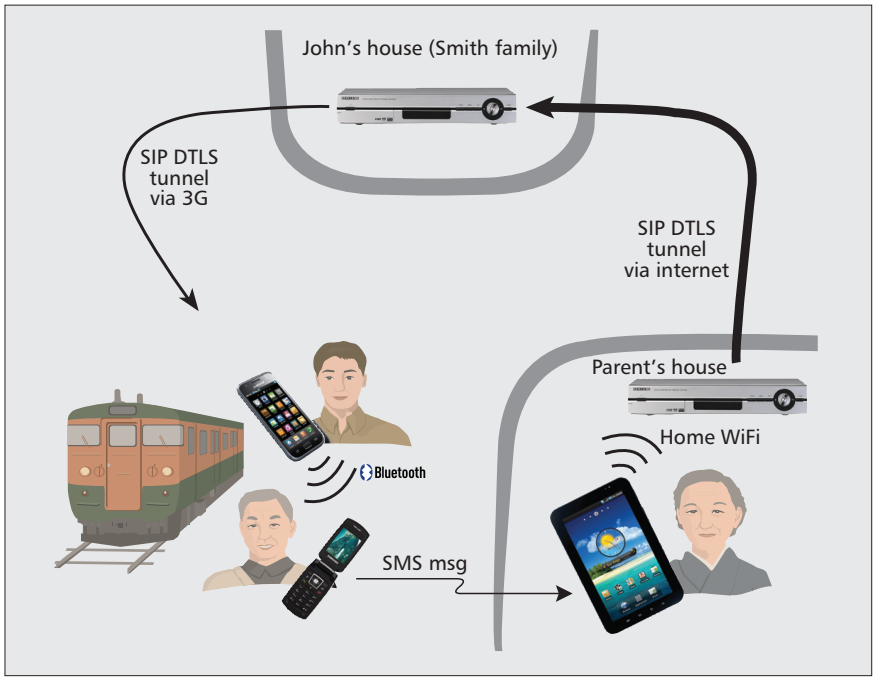
Problem: Design and deploy secure social sharing of rich media without a large centralized infrastructure requirement.

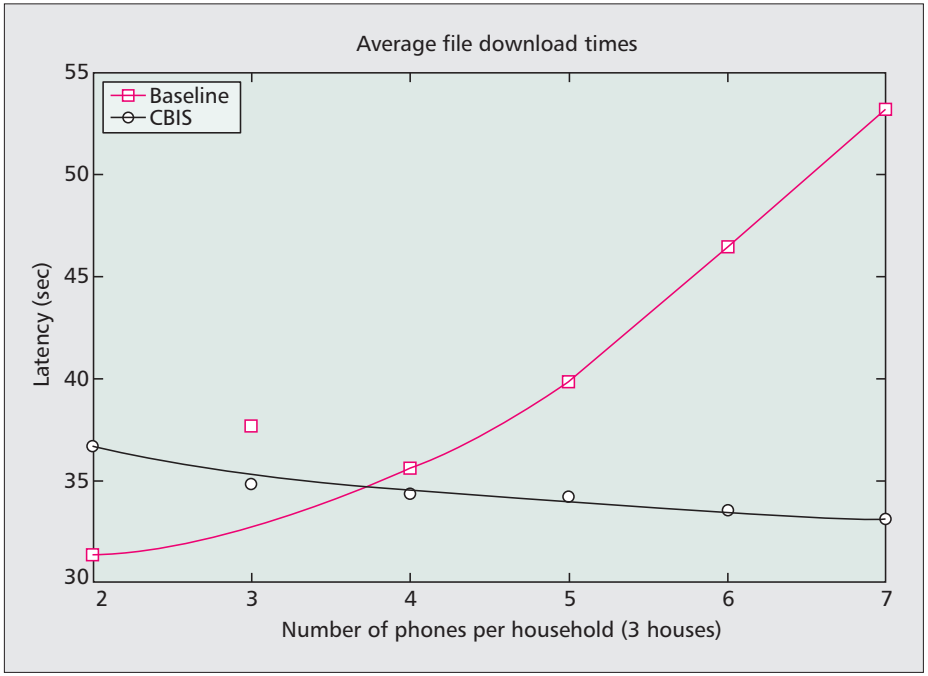
Solution: Fully distributed and secure photo-sharing application with viral routing information and content sharing with all access defined and managed by users.

Outcome: Multiple patents, running system, development of security, trust, routing, content repository, synchronization protocol and mobile device implementations for CCNx Open Source.

Project: Custodian-Based Information Sharing

Project Use Case





Experimental Results: Download Time

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Project: Content Distribution Streaming Improvement

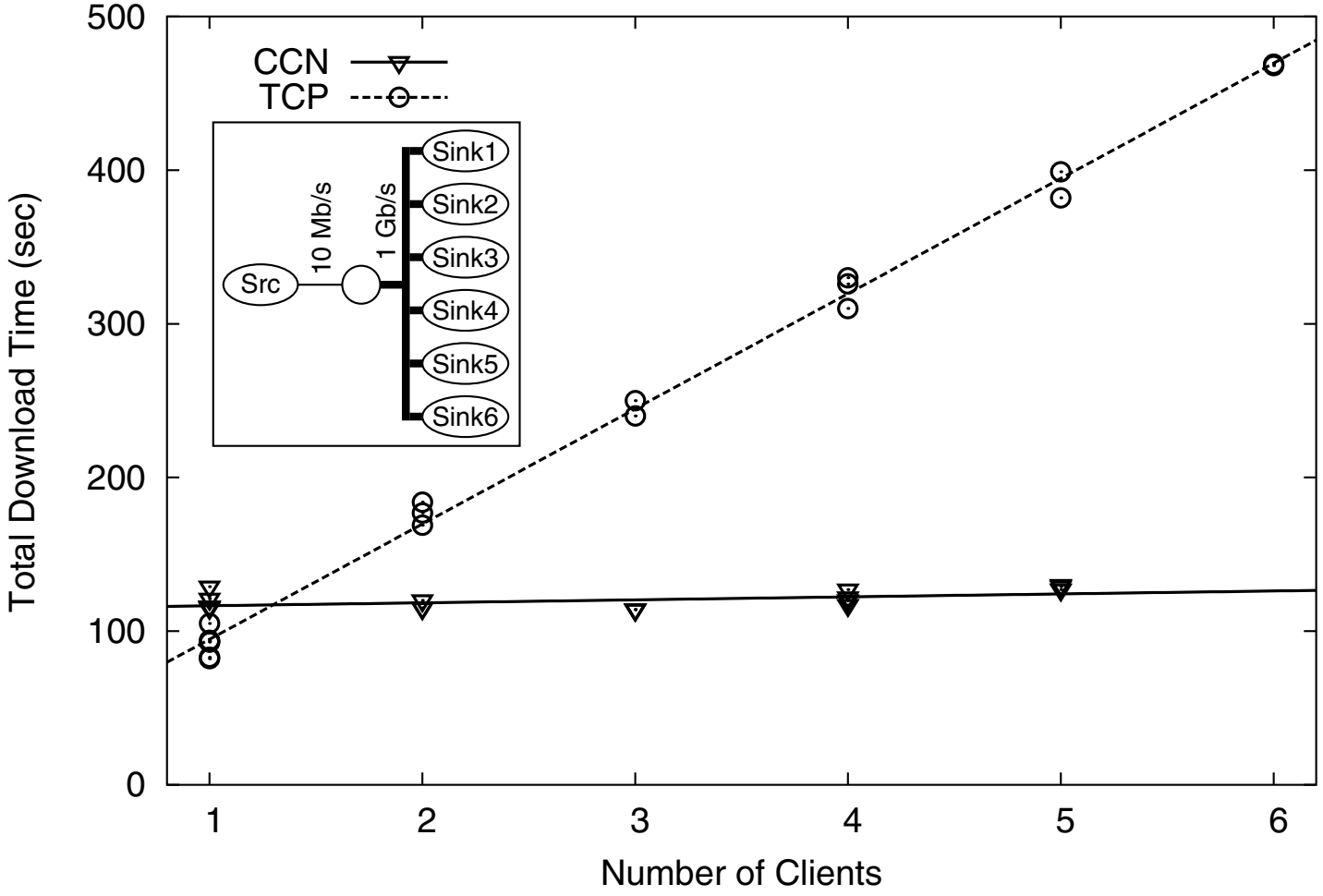
Industry: Consumer Electronics (major Korean conglomerate)

Problem: Deploying, configuring and maintaining Content delivery systems based on hosted infrastructure is complicated and may have poor performance. Can CCN overcome these difficulties and reduce need and complication of service over deployment and subscription?).

Solution: Development of predictive content fetching and improved Interest propagation protocols to reduce discovery time for locating requested content.

Outcome: Patents covering intelligent predictive content object retrieval, improved implementation of strategy layer in CCNx, evaluation and analysis of multiple strategy layer implementations and pipelining strategies. The use of CCN as the foundation of the cloud-based CDN decreased user-observed latency, masked link/machine failure and reduces network (control and data) traffic.

Project: Content Distribution Streaming Improvement



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Project: Real-Time Content Delivery

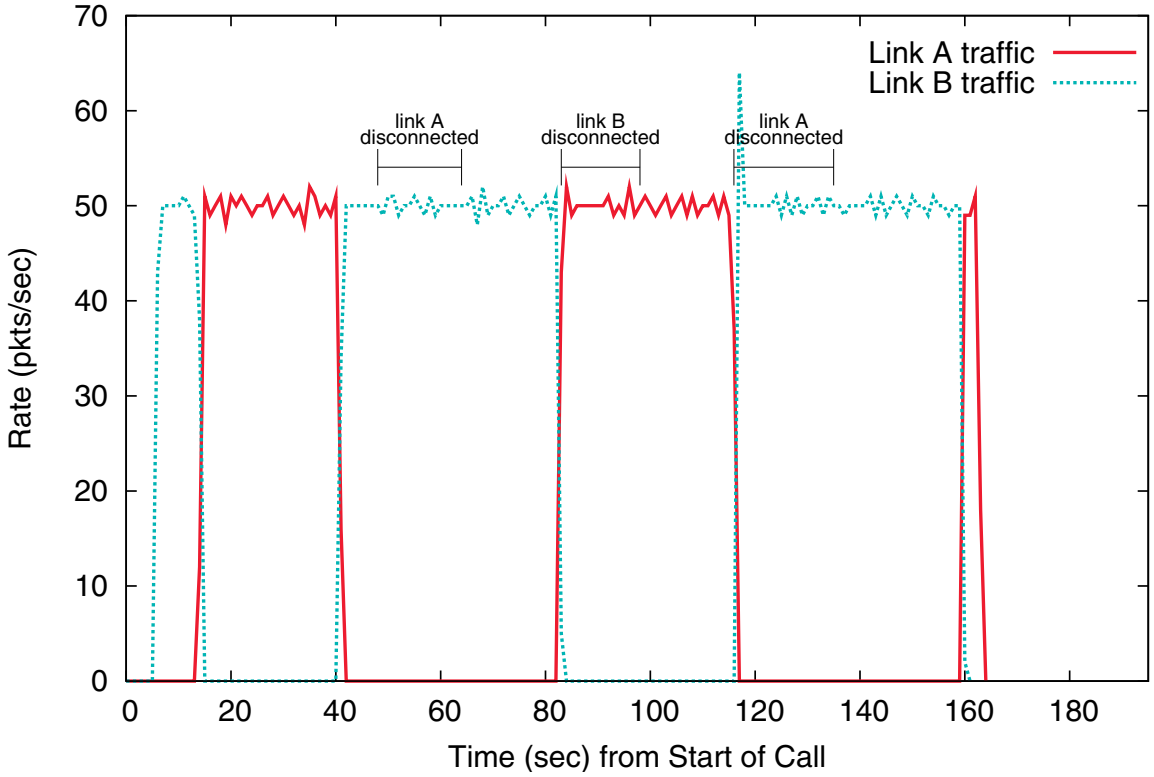
Industry: Consumer Electronics (major Japanese Conglomerate)

Problem: Content-based networking for media and file downloads may be intuitive, can CCN handle real-time workloads?

Solution: Design and implementation of a CCN transport for a VoIP application.

Outcome: VoCCN: CCN-based transport for Linphone (patents, implementation, paper).

Project: Real-Time Content Delivery



CCN natively utilizes multiple independent physical links to mask in-network link/node failures from applications.

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Project: HTTP Proxy

Industry: Network Equipment (major Chinese conglomerate)

Problem: Develop understanding and current state-of-the-art for network architecture directions.

Solution: Development of client-specific survey papers and comparison analysis for multiple network architecture redesign projects. Development of a proof-of-concept deployment strategy for an HTTP proxy.

Outcome: Design, development and release of the CCN-HTTP proxy.

Project: Scalable CCN Deployment

Industry: Consumer Electronics, Network Provider, Services, Academia (major Korean conglomerates, government and university)

Problem: Lack of large-scale system deployment analysis.

Solution: Advisory role to large-scale deployment, evaluation and analysis on PlanetLab and wireless testbed.

Outcome: Evaluation of incremental deployment strategy on ~100 PlanetLab nodes; results show significant performance improvements in download latency with about 20% nodes running CCN.

Project: CBMEN Content-Based Mobile Edge Networks

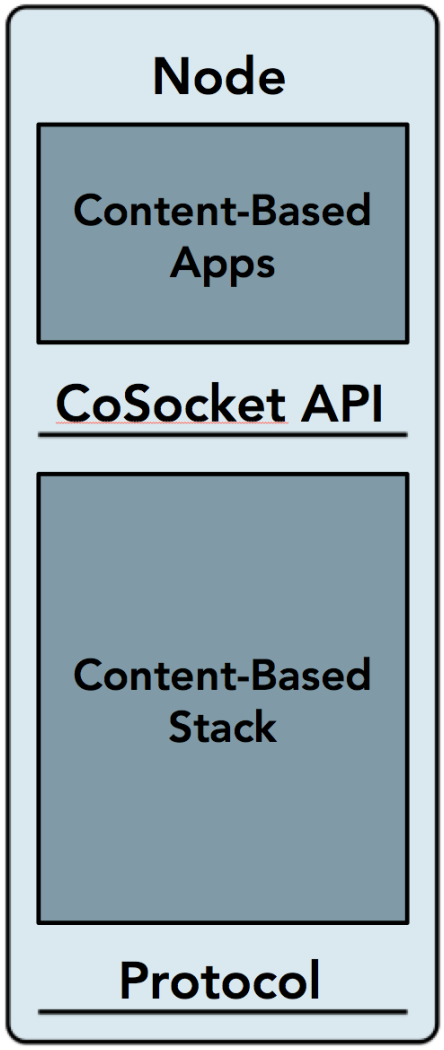
Industry: Government (DARPA)

Problem: Develop working knowledge and general understanding of application of new network architectures to solve on-the-ground content dissemination for soldiers.

Solution: Advisory role for multi-approach project prototyping network architectures. Initial steps towards standardization for the emerging area of content-based/ Information-Centric Networking.

Outcome: Implementation and evaluation of multiple options led to deeper understanding of solder's/deployment requirements. A clear need for meaningful and cooperative multi-layer protocols and architectures was exposed. Additionally, understanding for the requirements of a high-level API for meta-data and context labeling for content production, discovery and dissemination.

Project: CBMEN Content-Based Mobile Edge Networks



CBMEN Node Architecture

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Project: CCN Cloud Infrastructure

Industry: Services (major US conglomerate)

Problem: Deployment and coordination for necessary components in cloud infrastructure systems is overly complicated and fragile. Coordinating across data centers is often avoided due to messaging and control complexity and overhead.

Solution: Design and development of CCN plugins for OpenStack components.

Outcome: Problem validation of bottlenecked resources and time-to-deployment for cloud components, design and development of CCN plugins for Glance Image manager, RabbitMQ messaging layer and Swift object store.

Project: CCN Cloud Infrastructure

Current:

Problem: All clients are forced to connect to a centralized server, wasting bandwidth and severely limiting scalability and usability

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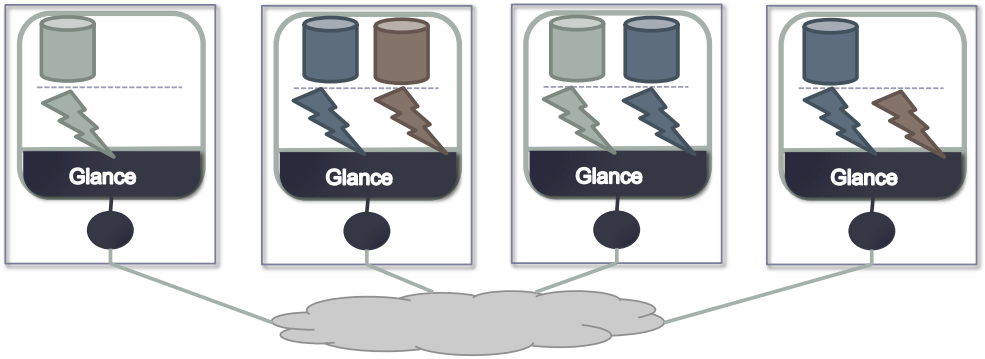
Future:



- Eliminate central servers, with logic distributed throughout network
- Applications are unchanged
- Scalable services with CCN-provided fault tolerance, adaptation and delivery

Distributed Glance Image Manager

Project: Project 42

Industry: Network Equipment

Problem: Industry is hard to penetrate and the un-proven reality of a CCN router.

Solution: Development of a programmable router able to efficiently implement CCN.

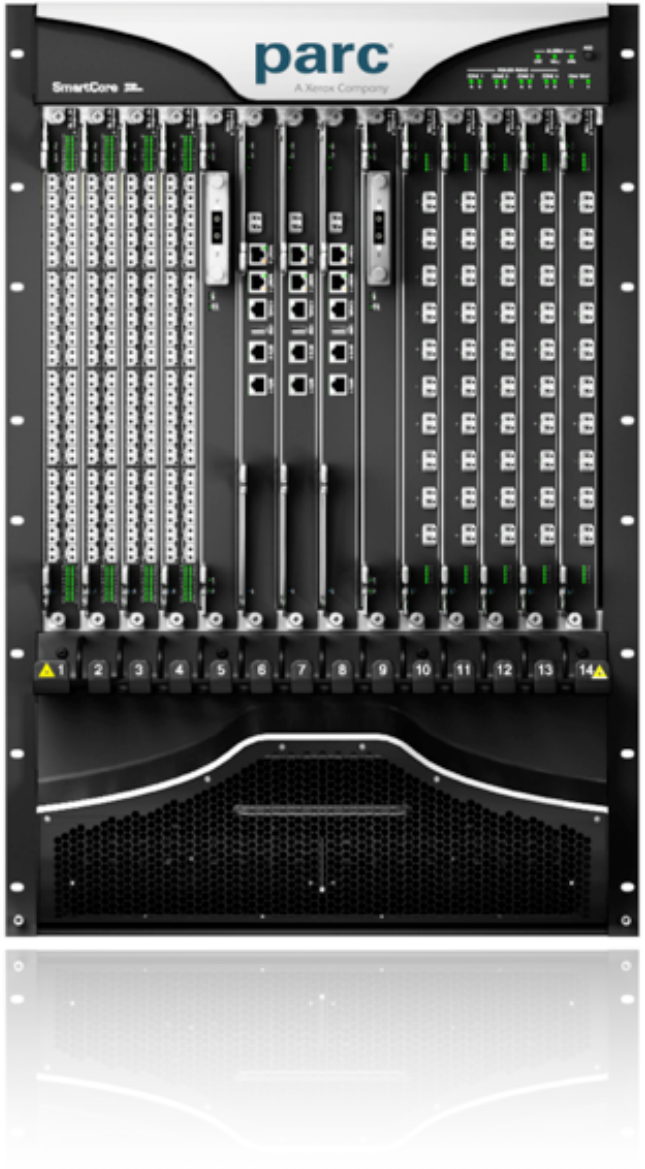
Outcome: Development of Penn and Teller along with an evolving CCN 1.0 ready for native deployment.

Project: Project 42

Penn

12 Terabit non-blocking fabric

14 slot chassis

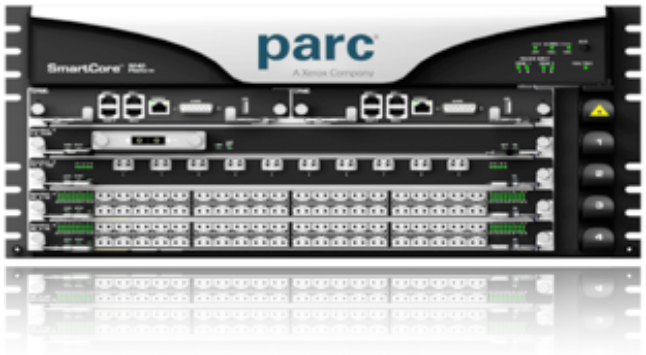


Teller

4.4 Terabit non-blocking fabric

6 slots chassis

1 Terabit per Slot
40x1GbE
10x10GbE
20x1GbE + 5x10GbE
100GbE



Making it Real

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Project: CCN over EC2

Industry: Consumer Electronics (major Korean conglomerate)

Problem: Deploying CCN for a CDN is often seen as a problem of infrastructure or adoption. Can CCN effectively be used as an architecture layered on top of an existing hosting service.

Solution: Solution: Run CCN as a CDN foundation over Amazon's EC2.

Outcome: Run CCN as a CDN foundation over Amazon's EC2.

Project: SAIM: Spatially Aware In-Memory Database

Industry: Government (DARPA)

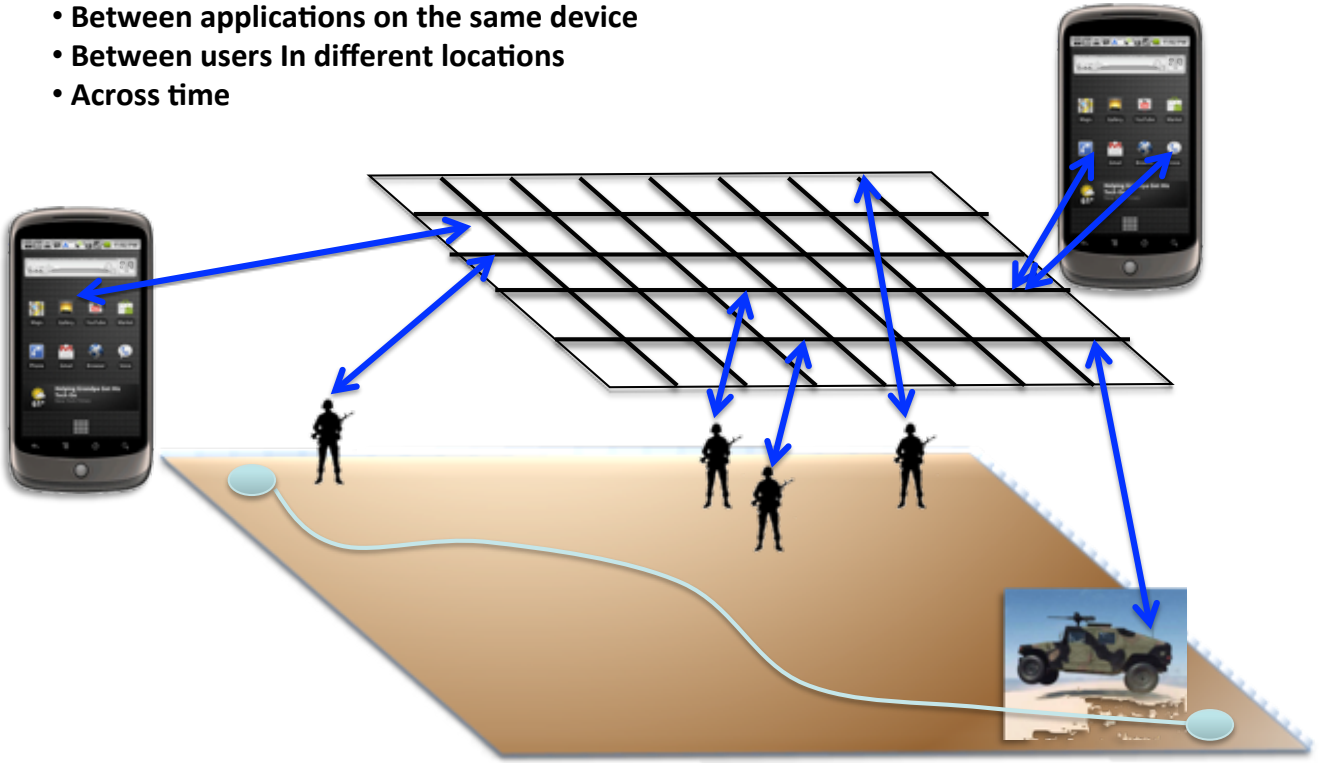
Problem: Writing spatially aware applications generally demands innovative approaches in spatial data structures, network communication protocols and other areas. When a peer-to-peer approach is taken to data distribution, the complexity of generating such an application increases greatly.

Solution: SAIM, which is aimed at reducing the burden of writing such a spatial application, while allowing for advanced bandwidth economical peering data distribution.

Outcome: Architecture, design and proposal.

Project: SAIM: Spatially Aware In-Memory Database

- **Distributed secure peer-peer spatial database for sharing real-world data**
  - **Between applications on the same device**
  - **Between users In different locations**
  - **Across time**



SAIM Overview

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Project: Improving Broadcast Mediums via CCN

Industry: Government

Problem: Broadcast mediums, specifically wireless for this proposal, suffer from under-utilization and wasteful control traffic

Solution: Utilize storage and broadcast nature of the nodes and communication medium to achieve full potential of the network capacity

Outcome: Architecture and internal white paper.

Project: Video Streaming

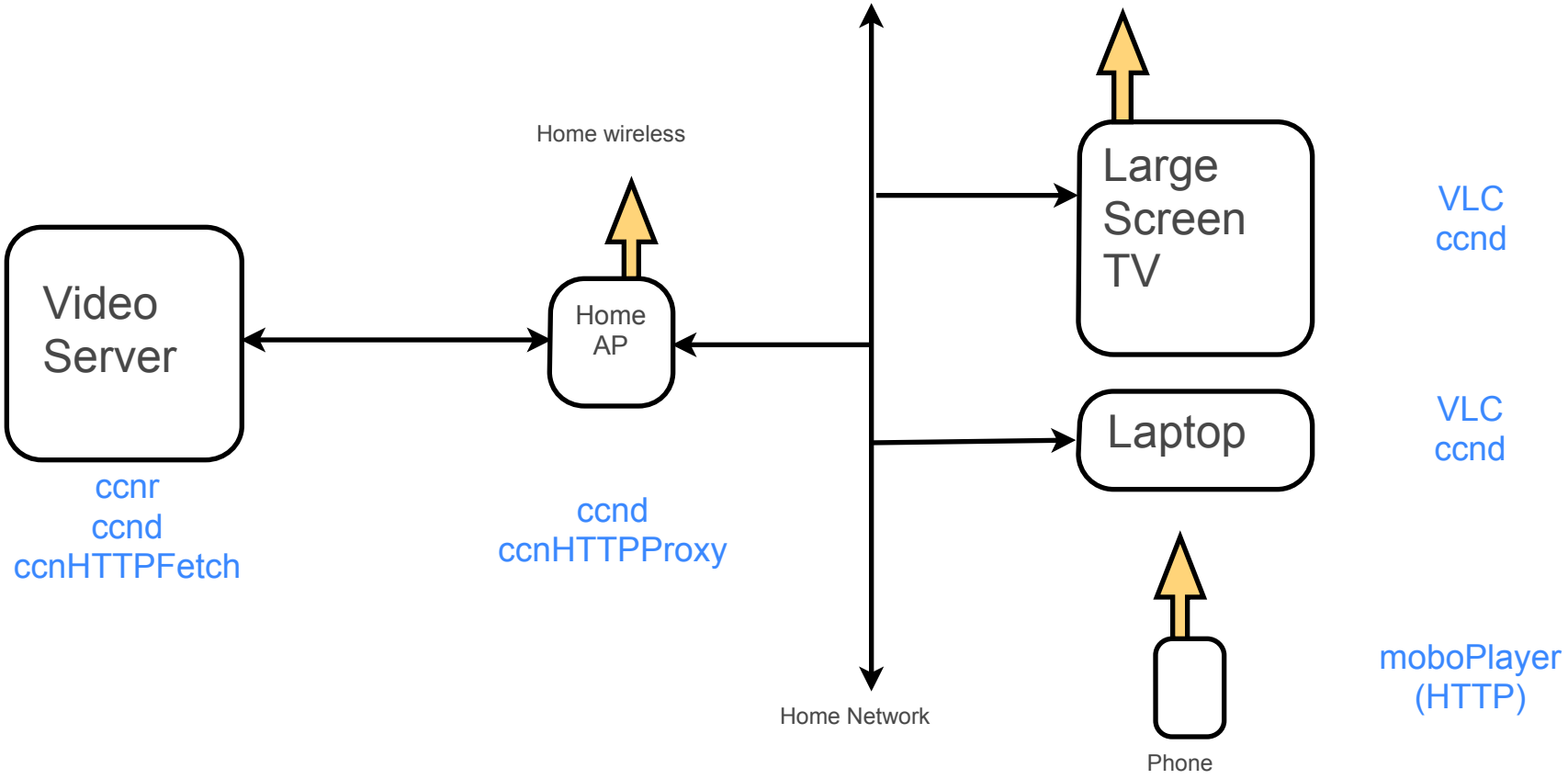
Industry: Services

Problem: Point-to-point connections unnecessarily place redundant traffic on specific network links and require capacity to replicate hosting nodes to handle connections for popular content.

Solution: Implement CCN-based video streaming to reduce network traffic and recover from in-network link/node failures.

Outcome: VLC plugin (available in CCNx)

Project: Video Streaming



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Project: CCN on Small Devices

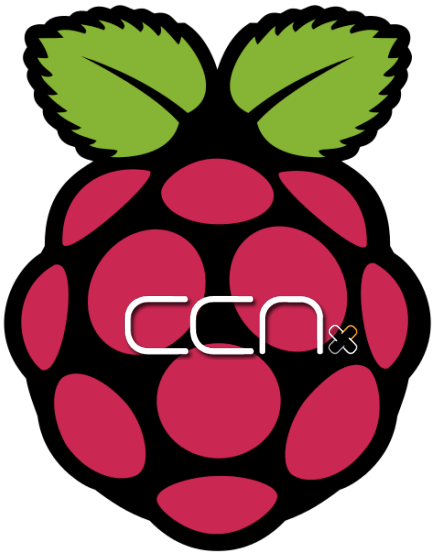
Industry: Network Equipment

Problem: Feasibility of constrained devices running CCN

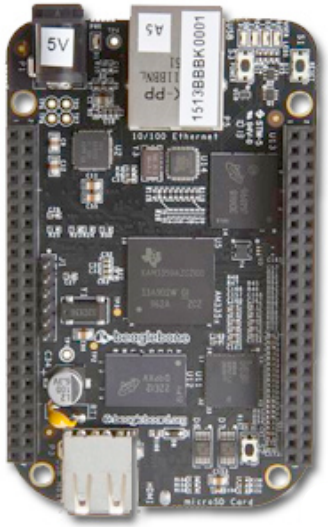
Solution: Compiled CCNx for specific platforms (ie. compile on the device for the device). Installed and ran without modification

Outcome: RaspPi, BeagleBone

Project: CCN on Small Devices



700MHz ARM
512 MB RAM
1.5 Watts
USB x2
Ethernet
HDMI
$35



AM335x 1GHz ARM Cortex-A8
512MB DDR3 RAM
2.3 Watt peak kernel load
USB
Ethernet
HDMI
$45

Project: CCN + OpenWRT

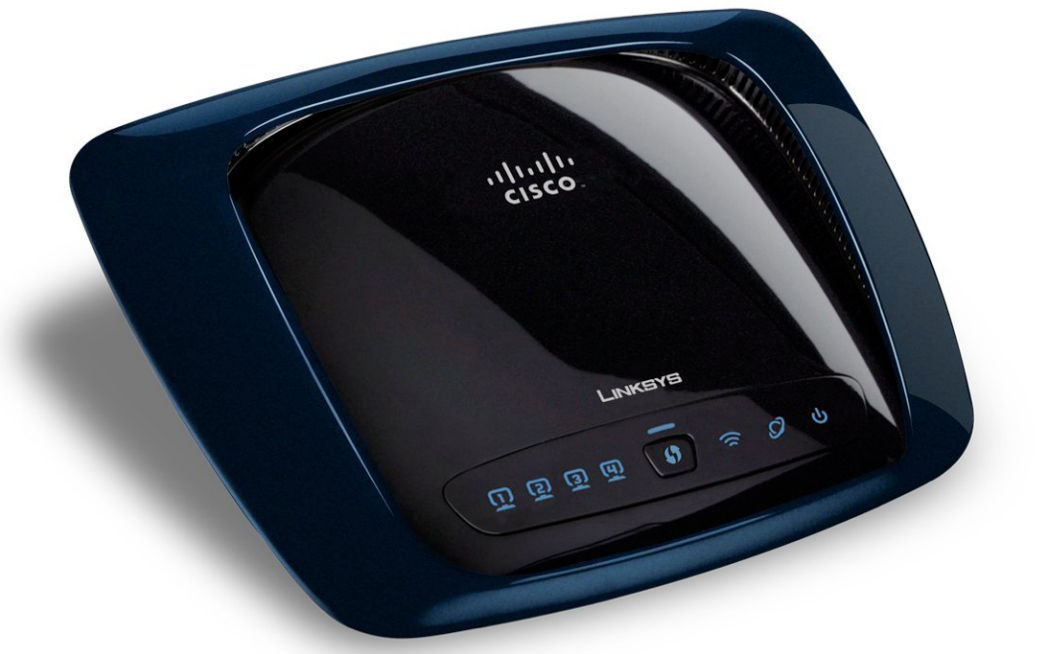
Industry: Consumer Electronics and Services

Problem: Proof-of-concept that CCN can run on a small constrained device.

Solution: Compiled CCNx Daemon for OpenWRT and installed on access point.

Outcome: Used in video streaming demos and general testing for CCN deployments and testing.

Project: CCN + OpenWRT



CCN Enabled Access Point

Project: CCN Wireshark

Industry: Testing and Support

Problem: Wireshark is a standard tool for analyzing network traffic. It did not natively handle CCN traffic.

Solution: Implement wireshark plugin to parse and display CCN Interests and Content Objects.

Outcome: Released code in CCNx open source.

Project: CCN for Health Care

Industry: Healthcare

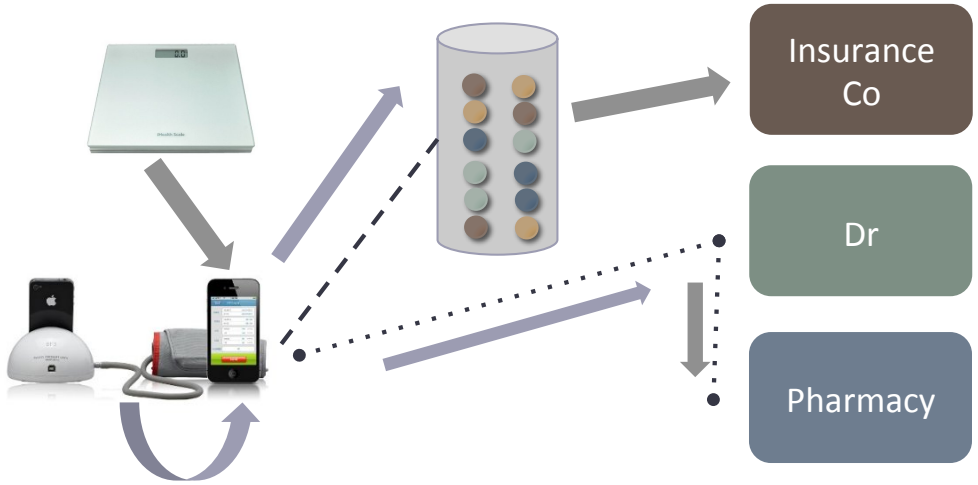
Problem: Health and wellness data is managed poorly. Ad hoc transmission and management. Data loses any provenance it may have had.

Solution: Implement a CCN-based healthcare demo to show how identity management, trust, verification, provenance and access control can be used to build trusted systems that can be effectively used to increase data available to medical professionals and personal applications and uses.

Outcome: Basic prototype implemented, full design completed. validated with several medical companies (services and device manufacturers).

Project: CCN for Health Care

Health and wellness data is severely segregated. If backup, recovery or remote access is even available, i often hastily constructed and fragile.



Mobile devices become health hubs - providing data availability to providers based on security settings. They can transmit data to remote services, making it available to providers or other users/devices. Clinics or pharmacies can directly access the data upon arrival of a patient with a mobile health hub through opportunistic connectivity.

Health Care: Security and Provenance of Your Data

Project: CCN Video Conferencing

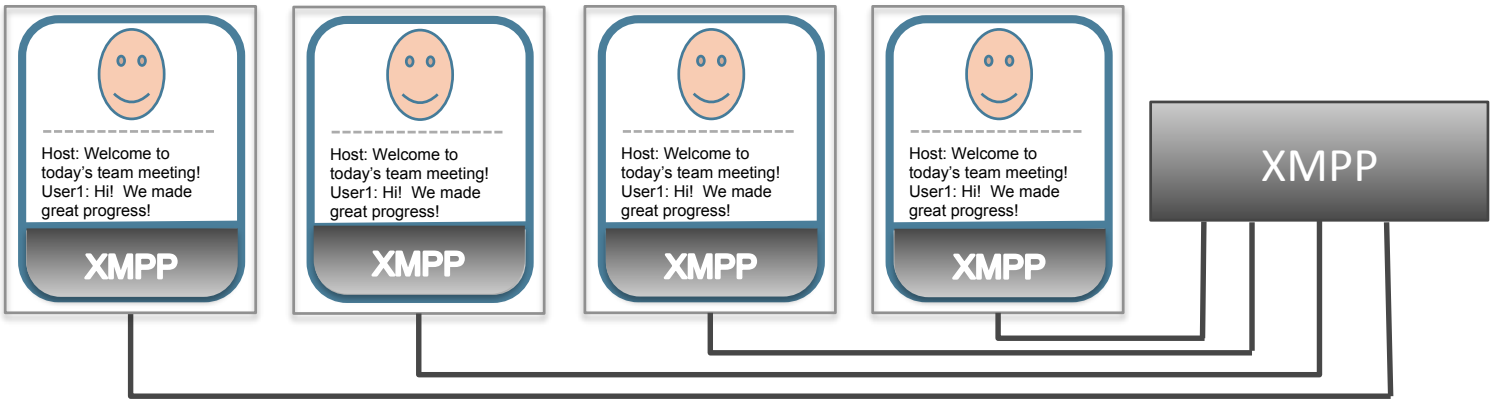
Industry: Services

Problem: Clients are typically forced to connect to a centralized server, wasting bandwidth and limiting scalability.

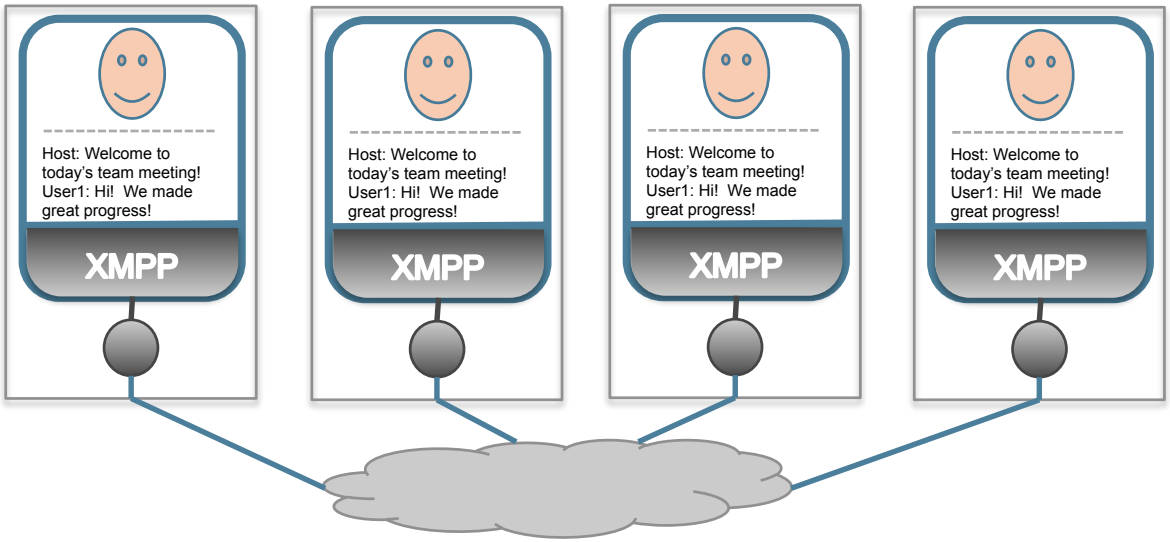
Solution: Without modifying existing applications, CCN eliminates central servers and replaces them by logic distributed in the network.

Outcome: Design and initial steps to implementation. NDN implemented and released ACT: Audio Conferencing Tool using NDN sync.

Project: CCN Video Conferencing



Problem: All clients are forced to connect to a centralized server, wasting bandwidth and severely limiting scalability and usability.



Without modifying existing applications, CCN allows central servers to be eliminated by distributing the logic throughout the network. This results in fully scalable services with CCN-provided fault tolerance, adaptation and efficient delivery.

Transforming Centralized Services

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Project: Fully Distributed "Dropbox"

Industry: Services

Problem: File sync is often implemented as a server-based service that requires coordination to an external machine. It is also hard to implement access control for parts of the stored filesystem (when that hierarchy exists).

Solution: Implement FileSync on CCN to remove the configuration difficulties and exhibit the benefits of local communication and fully distributed design.

Outcome: "CCN Hackday" product. Demonstrated at ENC Spring 2013 Summit.

Project: CCN Browser

Industry: Services

Problem: Adopting CCN is a difficult road without easy means to encourage application developers to utilize CCN at higher levels.

Solution: Firefox plugin to ease incorporation by application and website developers.

Outcome: Internal development and demonstration at ENC Spring 2013 summit.

Project: CCN-lite

Industry: Academia

Problem: The full CCN library contains many extensions that may not be useful as an introduction to the architecture or for certain deployments. Create a lightweight version for education and deployments

Solution: CCN-lite is a lightweight (no bells & whistles), and functionally interoperable implementation of the Content Centric Networking protocol CCNx of PARC. It is meant for use in class room work, experimental extensions, CCN relays running on resource constraint devices, and for commercial products

Outcome: Implemented and available for download from http://www.ccn-lite.net

Project: CCN for Green Networking

Industry: Network Equipment (major US conglomerate)

Problem: Redundant traffic is wasting network bandwidth.

Solution: Utilize CCN's architecture and native caching to reduce load on network.

Outcome: Simulation and publication.

Project: CCN for Green Networking

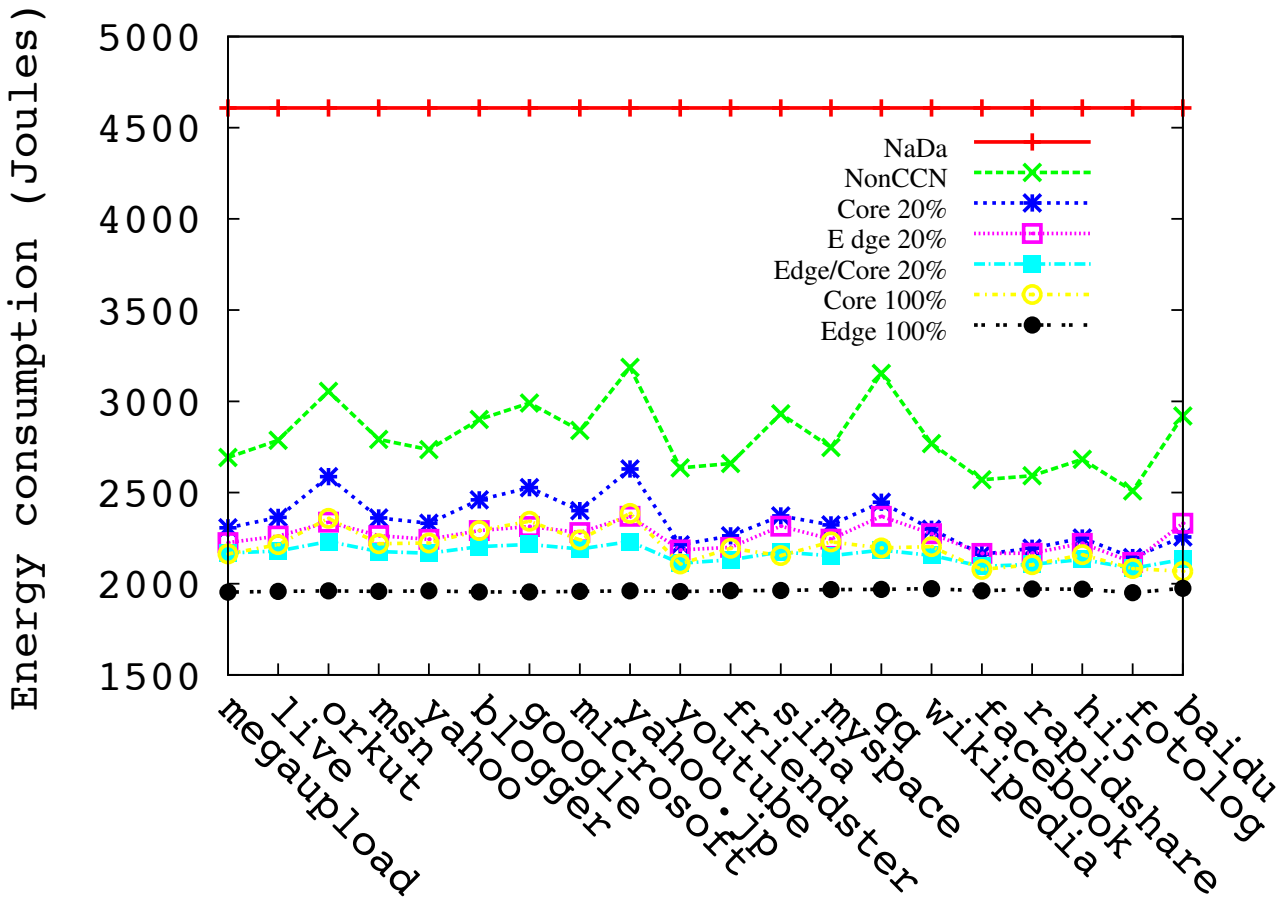


Figure 4: Energy consumption comparison

Uichin Lee, Ivica Rimac, and Volker Hilt. 2010. Greening the internet with content-centric networking. In *Proceedings of the 1st International Conference on Energy-Efficient Computing and Networking* (e-Energy '10). ACM, New York, NY, USA, 179-182.

Conserve by Reducing Network Burden

Project: Music Streaming and Production (NDN)

Industry: Academia

Problem: Video and audio production is often a centralized service. Producing live streams from multiple cameras and microphones by mixing on the fly at the receiver is not possible today.

Solution: Implement CCN enabled cameras and microphones to allow clients to mix streams/feeds on demand.

Outcome: Demonstration of a musician performing in a studio, live.

Project: Video Streaming (NDN)

Industry: Academia

Problem: Video streaming is a high traffic application and can overwhelm a network with multiple clients retrieving the feeds.

Solution: Co-locate CCN node to proxy camera video feed to NDN testbed to exhibit CCN's ability to reduce network load.

Outcome: Implemented and deployed.

Project: Studio Light Control (NDN)

Industry: Academia, Entertainment, Internet-of-Things

Problem: Configuration and control of 100s to 1000s of lights in a studio is tedious and difficult to manage.

Solution: Deploy studio lighting with CCN architecture to simplify configuration and control.

Outcome: Implemented and used in demonstrations and studio use.

Project: CCN Git

Industry: Academia (major US university)

Problem: Proof-of-concept for a well-matched combination of technologies.

Solution: Modify git source to utilize CCN.

Outcome: Implemented, made available and published as a Tech Report by Columbia - Columbia Technical reports: “GRAND: Git Revisions As Named Data” - Jan Janak, Jae Woo Lee, Henning G. Schulzrinne.

Project: Direct DIrection REsilient Content Transport

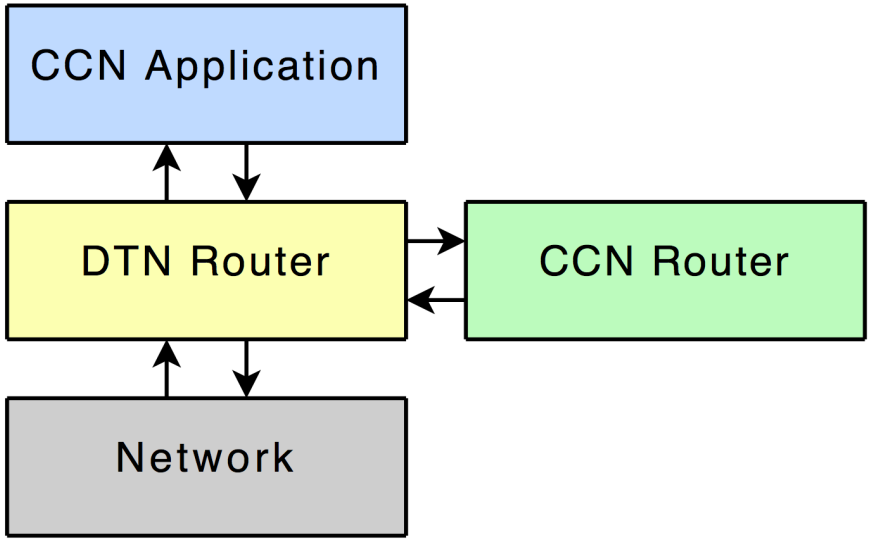
Industry: Government (DARPA)

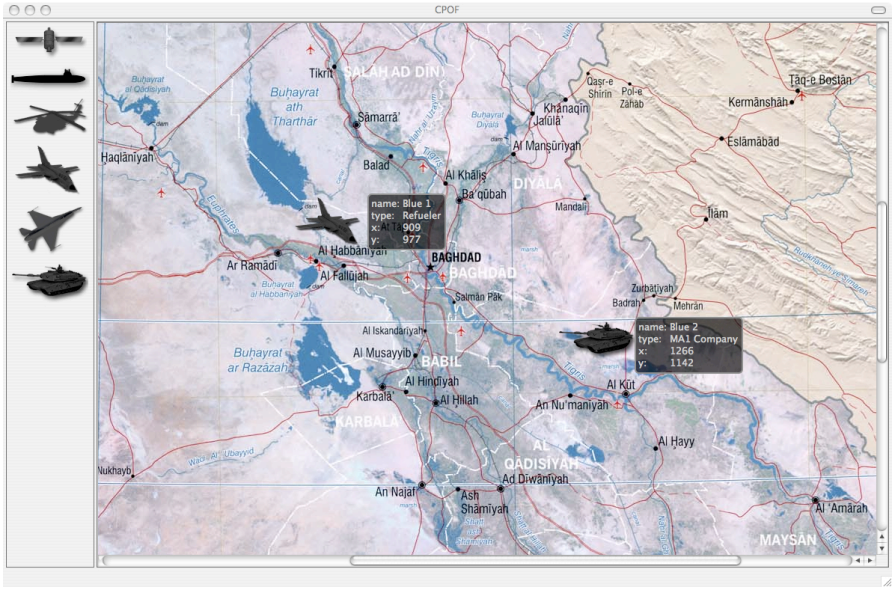
Problem: Soldiers communicating on the ground often experience disconnected networks. When communication is available, all possible paths need to be used with the mobility of devices creating temporary network paths. This intermittent connectivity is difficult to predict and is the only means to communicate between disjoint network partitions

Solution: DTN Content Based Network

Outcome: Used by ISI in CBMEN

Project: Direct DIrection REsilient Content Transport





DIRECT Architecture and Demo Scenario

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Project: WNAN Wireless Network After Next

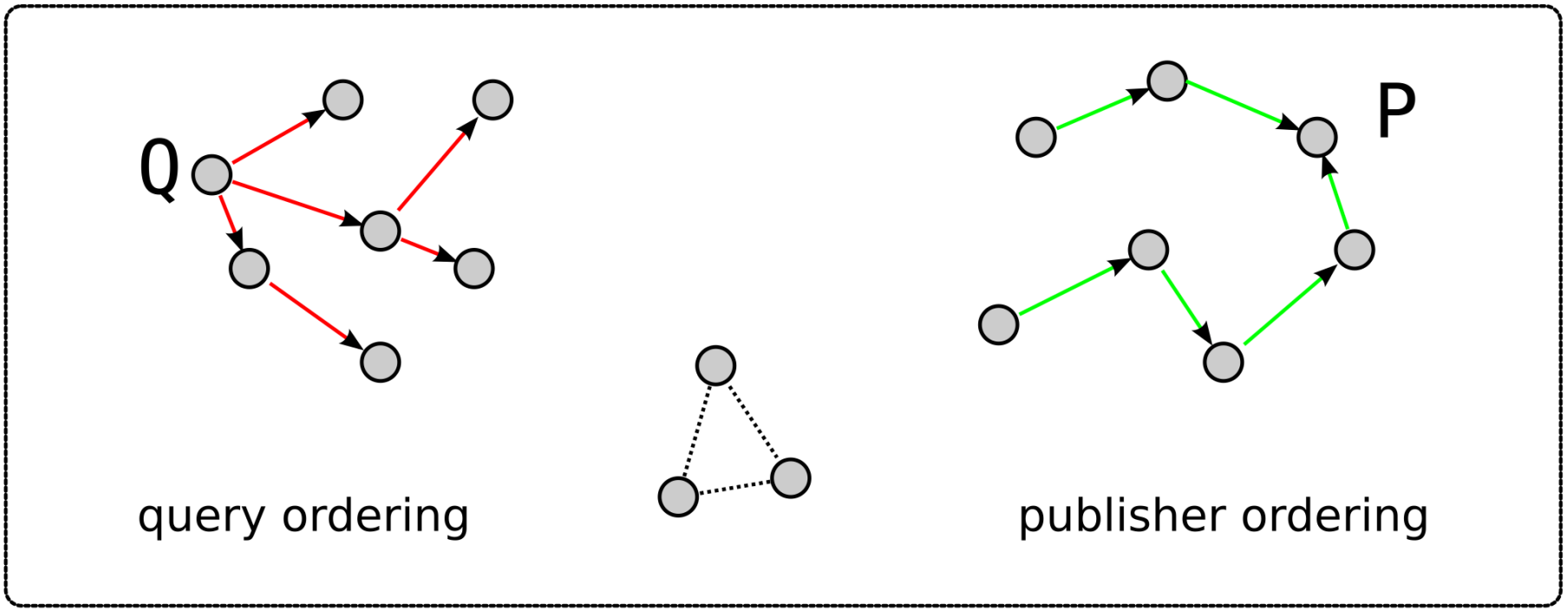
Industry: Government (DARPA)

Problem: Need for reliable and efficient networking in ad hoc networks.

Solution: Bidirectional content routing for ad hoc networks. Nodes can query for content and additionally advertise the presence/publication of new content.

Outcome: DOT: Dual-ordered Object Transport and FieldNote (network layer added in phase 2 - flooding on broadcast, network auto configuration, subscription based) .

Project: WNAN Wireless Network After Next



DOT: Dual-ordered Object Transport

Project: WNAN Wireless Network After Next

FieldNote

Project: Traq

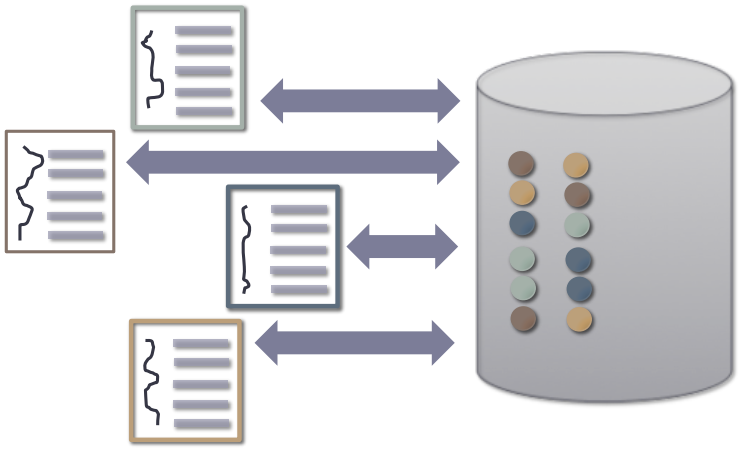
Industry: US Government

Problem: Transformative Apps program aimed at improving coordination between and empowering soldiers.

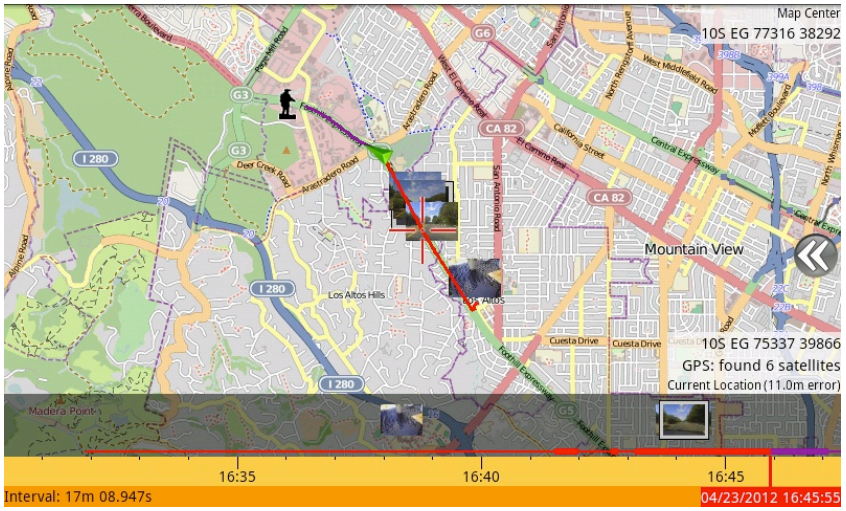
Solution: Development of Traq: Capture, tag and collect information from soldiers in the field.

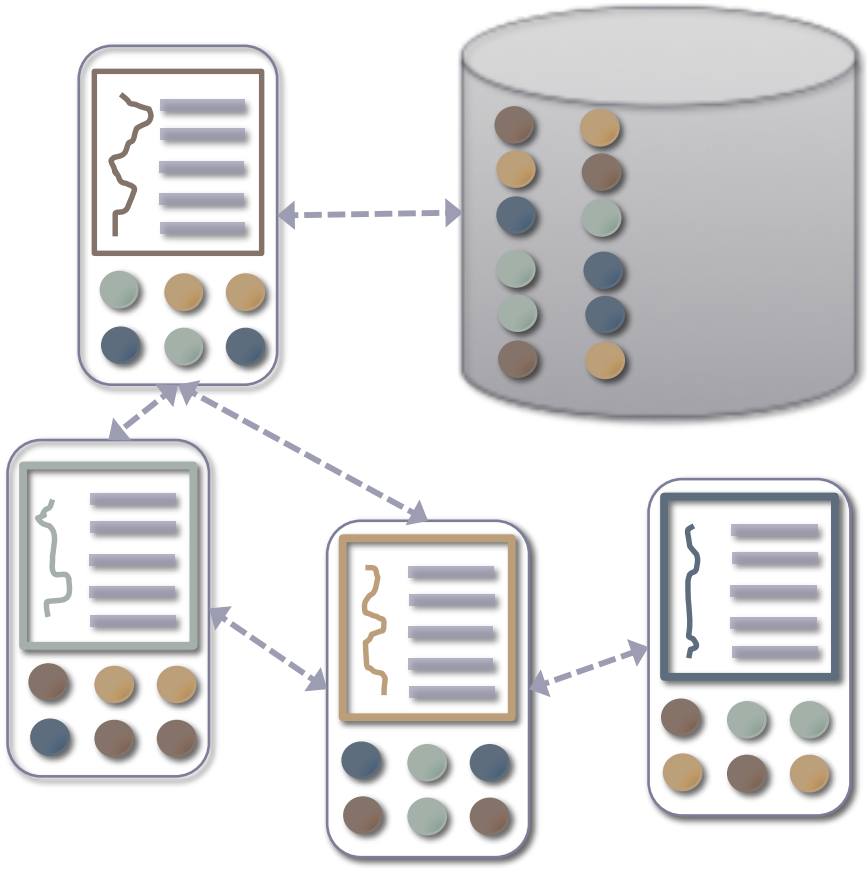
Outcome: Implemented for funded project - networking component added post-funding.

Project: Traq



Today: Devices individually responsible for uploading their data





CCN: network is a distributed storage layer, populating local caches through available connectivity.

Multi-Device Information Sharing

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Project: First Responder

Industry: Health and Emergency Services

Problem: Information dissemination is vital for First Responders in an emergency. Often, regular network communication is limited or unavailable.

Solution: Develop an ad hoc network infrastructure and application for triaging patients and coordinating between responders.

Outcome: Initial prototype developed.

Project: First Responder

FirstResponse

Project: INDEX: In-Network Data EXchange

Industry: Government, Commercial

Problem: Mobile nodes generate data all the time (images, audio, video, application data, etc). This information might be relevant to nearby nodes flooding the network with unnecessary traffic.

Solution: In Network Data Exchange created application level catalog files of information. Information was shared with nearby peer nodes presenting the application a view of the data that included the locally available data and nearby available data.

Outcome: A prototype was built using CCN. We instrumented the Android Media Store to share catalogs of the available media such that nearby devices would see the pictures and videos available on nearby devices on the local applications. By leveraging the Android MediaStore framework no modifications were needed to local applications to use this feature.

Project: lib-DASH

Industry: Academia

Problem: Dynamic Adaptive Streaming over Content Centric Networks (DASC áka DASH over CCN), which implements MPEG Dynamic Adaptive Streaming over HTTP (DASH) utilizing a Content Centric Networking (CCN) naming scheme to identify content segments in a CCN network.

Solution: Content Centric Networking is used to deliver video segments formatted according to MPEG-DASH in different quality levels.

Outcome: Implementation and publication - Quote from paper summary: “DASH over CCN can definitely compete with HTTP 1.0, showing the same RTT-sensibility characteristics and slightly outperforming it already in scenarios with high network delay. Considering the prototype implementation of CCN and the modification possibilities proposed in this paper, DASH over CCN has the possibility to outperform HTTP 1.0 and strive towards the efficiency of HTTP 1.1.

Project: lib-DASH

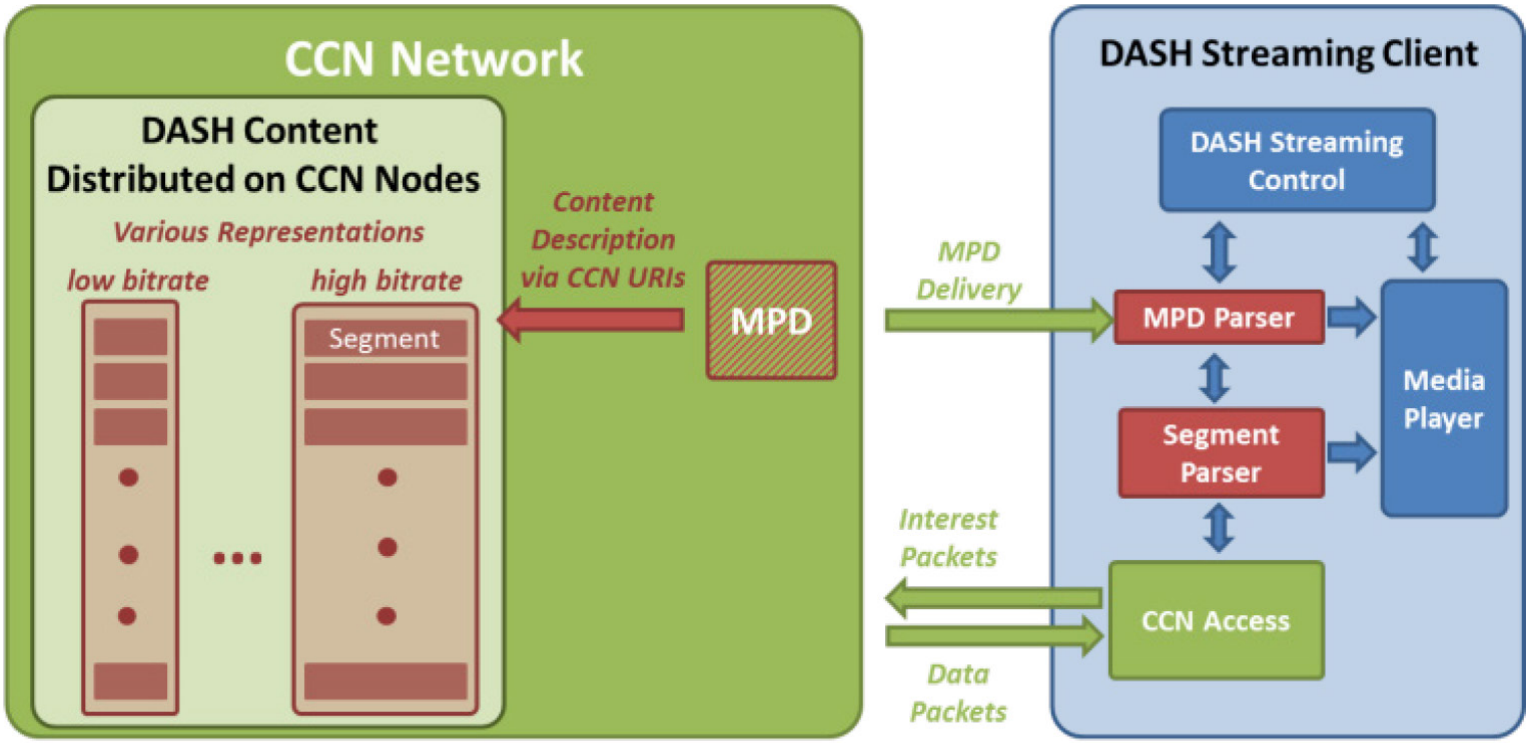

Figure 1: DASH over CCN

lib-DASH over CCN Architecture

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Project: CCN Visualizer

Industry: Testing (major British communications concern)

Problem: Understanding deployed system behavior is difficult... visualizations needed

Solution: Implement d3 viz to understand where traffic is flowing on individual nodes and faces.

Outcome: Implemented and used for debugging and analysis.

Project: HTTP Live Streaming over CCN

Industry: Academia

Problem: proof-of-concept

Solution: Design and implement CCNx transport for Apple HTTP Live Streaming protocol.

Outcome: Implementation, analysis and publication (code is available).

http://netgroup.uniroma2.it/Stefano_Salsano/papers/salsano-wowmom12-ICN-cellular-video.pdf

code available: http://netgroup.uniroma2.it/Andrea_Detti/ICNvideo/

Project: Beyond DLNA with CCN

Industry: Consumer Electronics (major Korean conglomerate).

Problem: DLNA is an established standard for device interoperability, that solves many key consumer problems with media in the home through deployed products in the market today. We propose taking the next step of extending products with CCN to enable new features, without sacrificing backwards compatibility with DLNA.

Solution: Proposed "dual-stack" configuration (CCN alongside UPnP) allowing for simultaneous communication of Pure DLNA/UPnP, DLNA/UPnP over CCN and pure CCN. This paradigm offers new application functionality, pause points and additional advanced control, automated distribution, metadata, content remixes and internet content, social sharing, improved UI, Anycast and advanced security.

Outcome: Architecture and proposal.

Project: Mobile Phone Media Download

Industry: Consumer Electronics (major Korean conglomerate).

Problem: Multiple phones co-located cannot download media at the same time.

Solution: Implement CCN-based media transfer.

Outcome: Live-demo. Side-by-side comparison of 20 phones (standard and CCN-enabled). Most (if not all) of the standard phones fail, all CCN phones download the file successfully, and without playback hitches.

Project: Application Information Dissemination (AID)

Industry: Government

Problem: Prototype secure and robust information sharing in tactical networks.

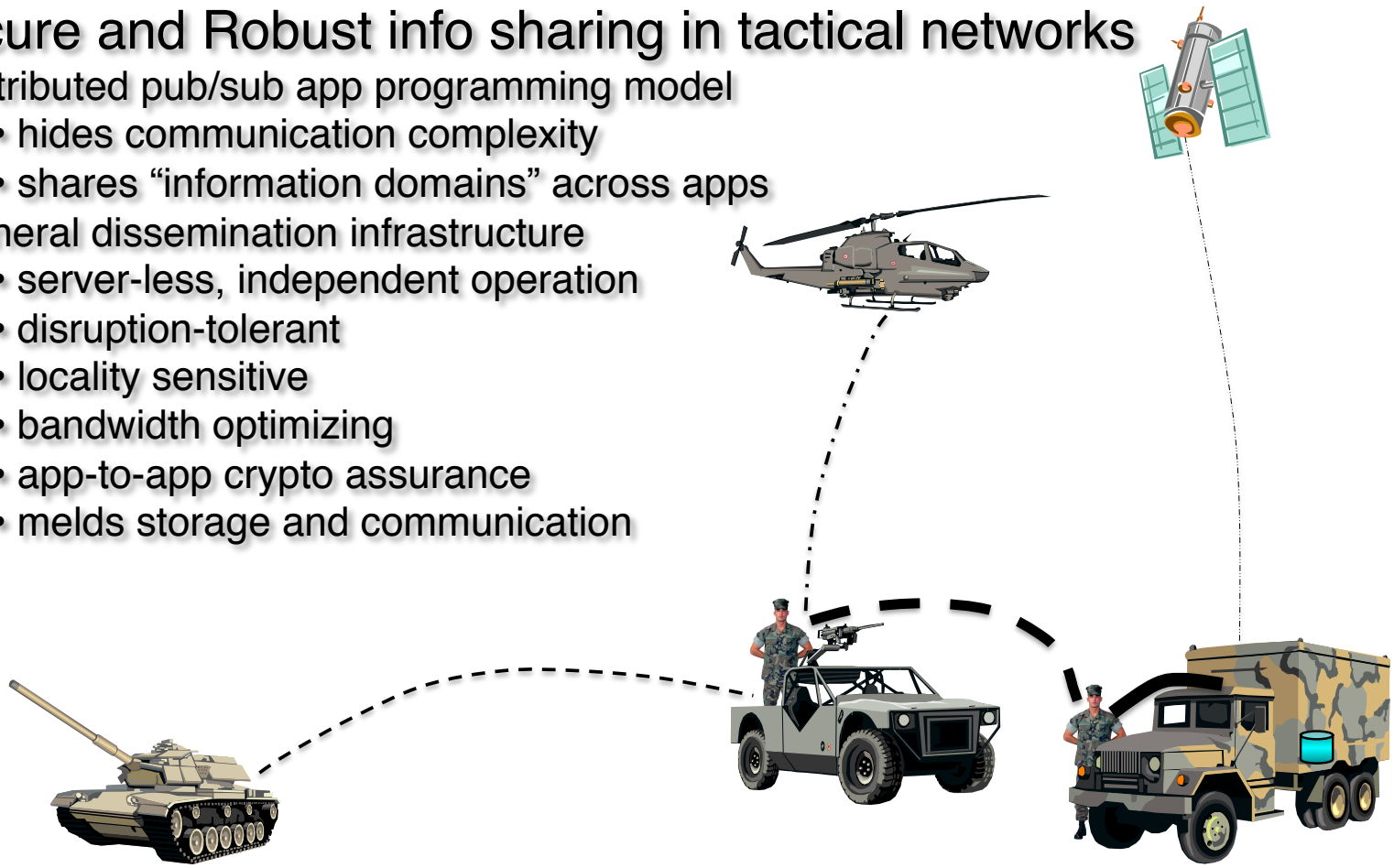
Solution: AID: Distributed pub/sub application programming model that hides communication complexity and shares “information domains” across applications.

Outcome: Architecture and proposal

Project: Application Information Dissemination (AID)

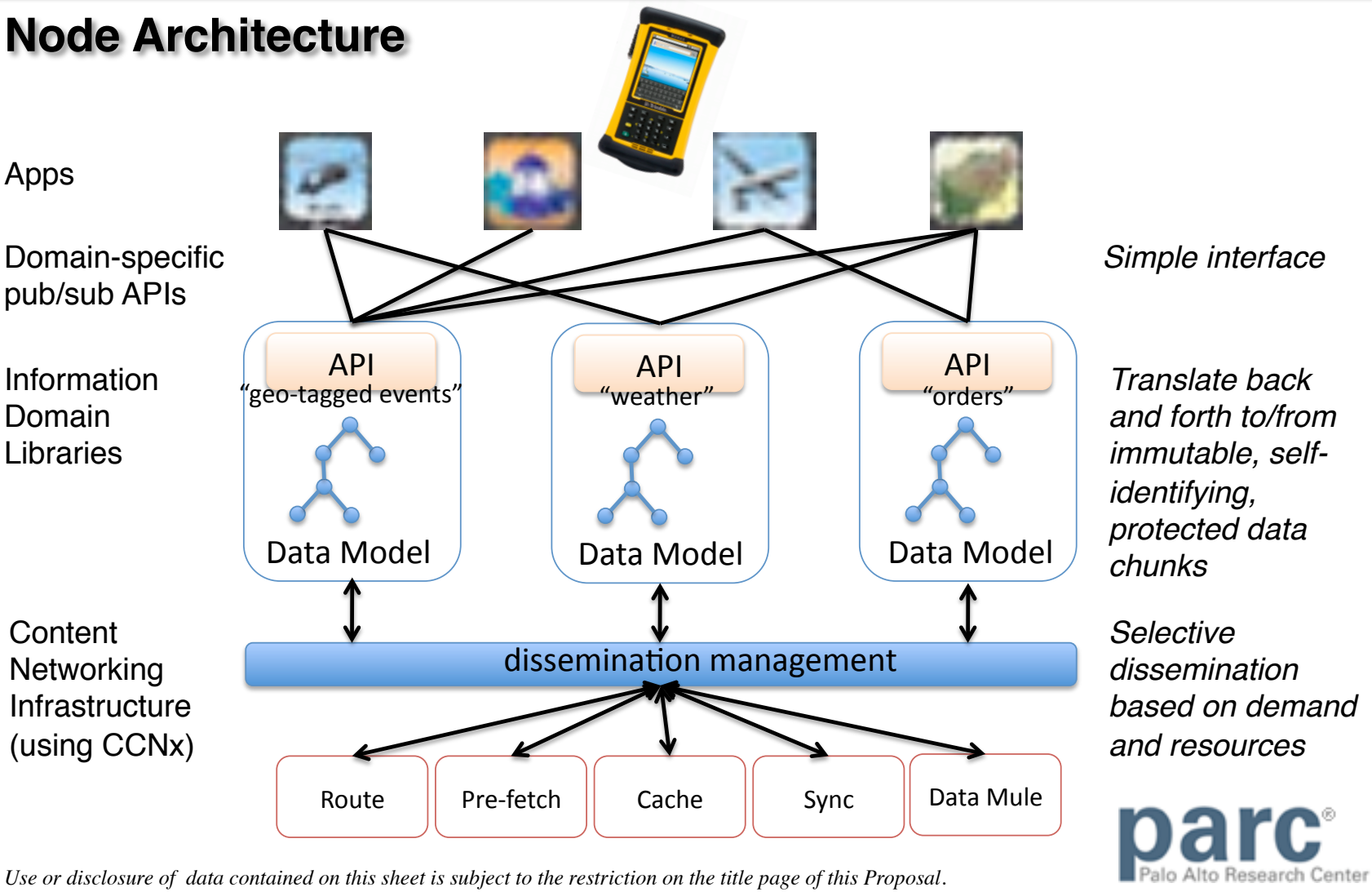
Secure and Robust info sharing in tactical networks

- Distributed pub/sub app programming model
  - hides communication complexity
  - shares “information domains” across apps
- General dissemination infrastructure
  - server-less, independent operation
  - disruption-tolerant
  - locality sensitive
  - bandwidth optimizing
  - app-to-app crypto assurance
  - melds storage and communication



AID: Application Information Dissemination

Project: Application Information Dissemination (AID)



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AID: Node Architecture

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Project: Group-Based Access Control

Industry: Consumer Electronics (major Korean conglomerate).

Problem: Efficiently distributing and sharing content is one part of the new application and network architecture, protecting it is also a vital component.

Solution: Design and implement group-based access control. Group management and access control for namespace manager additionally implemented.

Outcome: Implemented and released in CCNx.

Project: CCNx Content Explorer

Industry: Research

Problem: Dealing with content namespaces is hard to grasp initially. Needed to develop a familiar view to help others understand the use of names.

Solution: Implement Content Explorer that looks very similar to a file system finder window. Additionally implemented the ability to view version names of content and preview files.

Outcome: Implemented and released in CCNx.

Project: Namespace Visualizer

Industry: Research

Problem: Understanding what names are being used in a repo/ccnd/snapshot can be a tedious task of reading logs. Need to develop a user-friendly way to see names in action.

Solution: Implement namespace visualizer in a browser friendly environment (d3.js).

Outcome: In development.

Project: Java Media Player Plugin

Industry: Research

Problem: Needed proof-of-concept for streaming media.

Solution: implement CCNx transport for Java Media Player.

Outcome: Implemented and released for CCNx.

Project: SERENE

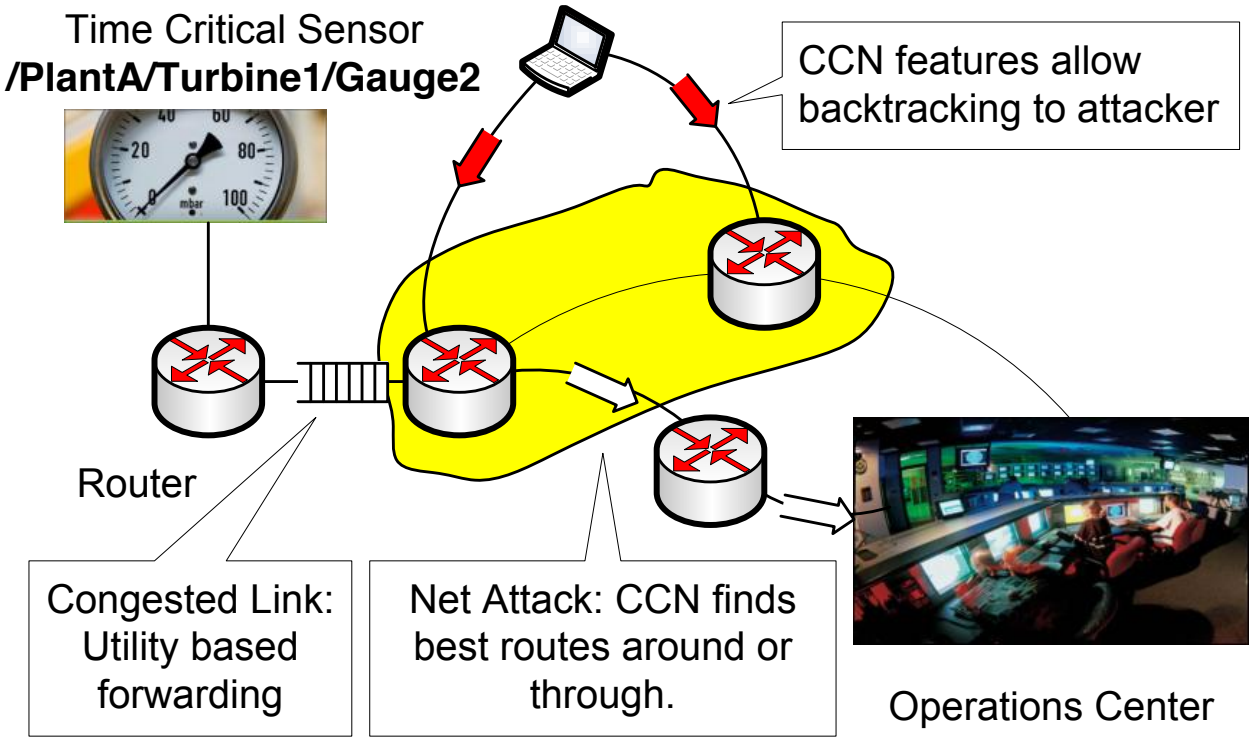
Industry: Government - DARPA

Problem: Explicit request for Survivable Time-Critical Systems. Communication on the ground is susceptible to single points of failure, data corruption and spoofing.

Solution: Design and implement a named data Utility Model and Utility Based Routing by applying multi-path and multi-copy strategies to named data networks to exploit the placeless nature of content.

Outcome: Architecture and proposal

Project: SERENE



SERENE

Project: Release Tools

Industry: Research

Problem: Needed networking and diagnostic tools for building, deploying and testing CCN systems.

Solution: Implement utilities for displaying content, listing names, checking prefixes, exploring namespace, configuring routing

Outcome: Multiple tools released in CCNx, including, but not limited to: ccn_ccnbtoxml, ccn_xmltoccnb, ccndc, ccndcontrol, ccndlogging, ccndsmoketest, ccndstatus, ccndumpnames, ccndumppcap, ccnget, ccnls, etc.

Project: Content Repository

Industry: Research

Problem: Client project revealed the critical component of long-term storage at each node.

Solution: Implement an efficient content repository.

Outcome: Delivered to client and released in open-source

Project: CCN Sync

Industry: Services (major Korean conglomerate)

Problem: Needed to efficiently synchronize content at multiple applications and repositories.

Solution: Design and implementation of CCNSync.

Outcome: Delivered to client and released in CCNx.

Project: Sync API

Industry: Research (internally funded)

Problem: CCN Sync is a proven paradigm for building scalable and distributed applications. Incorporating it into applications was not straightforward.

Solution: Design and implement an application API for sync.

Outcome: Implemented and released in both C and Java CCNx libraries.

Project: File Management and Distribution

Industry: Research

Problem: Proof of concept for file use and manipulation with CCN.

Solution: Implementation of file publishing, download, meta-data management and access control.

Outcome: Implementation of C and Java file publishing and download, file system proxy and filesystem-like ccnrepols utility.

Project: Name Enumeration

Industry: Research

Problem: Exploring and utilizing the namespace is not always intuitive for application developers. Needed to develop a protocol and utility for exploring the active namespace.

Solution: Design and implementation of Name Enumeration (responder and requestor) and corresponding utilities. Additionally designed and implemented a “fast response” mode.

Outcome: Implemented as components for Java lib, implemented in ccnr and example use with ccnlsrepo.

Project: Ananda

Industry: Research

Problem: Privacy-preserving and censorship resistant communication.

Solution: Secure and efficient Onion routing in CCN.

Outcome: Andana application that is 2 to 3 times more efficient than ToR.

Project: Key generation and distribution for ndn testbed

Industry: Academia

Problem: Key generation, certification and distribution.

Solution: Hierarchical PKI.

Outcome: NDNkey application for NDN testbed.

Project: NDN Testbed Viz

Industry: Academia

Problem: Real-time visualization of testbed status.

Solution: real-time distributed data gathering over CCN.

Outcome: TestbedViz application.

Project: NDN Deer Cam

Industry: Academia

Problem: Monitoring and sensing deer activity in farmlands.

Solution: CCN based distributed sensing network.

Outcome: Deployed activity triggered monitoring system in Illinois.

Project: NDN Scalable and Resilient Demo

Industry: Academia

Problem: Show the scalability and the error resilience of CCN.

Solution: Amazon EC2 based large topology setup with random and frequent link failures.

Outcome: A public demo at GENI engineering conference.

Project: Minerva - pub/sub for smart phone

Industry: Academia

Problem: A stable pub/sub system for highly mobile clients.

Solution: CCN based pub/sub service and client application.

Outcome: Minerva application.

Project: chronoshare - using NDN sync

Industry: Academia

Problem: Fully distributed secure dropbox.

Solution: CCN based decentralized and secure architecture with near real-time synchronization.

Outcome: Chronoshare application.

Project: Python bindings

Industry: Academia

Problem: Python support for developing CCN applications.

Solution: Python bindings for CCN libraries.

Outcome: Open source library.

Project: Network Tools

Industry: Academia

Problem: Familiar network management tools for CCN.

Solution: Build equivalents for traceroute, ping, NDN AutoConf Server (dhcp) for CCN.

Outcome: Suite of the above network management applications.

Project: Proxy re-encryption DRM

Industry: Research

Problem: DRM solution for CCN that can effectively utilize caches in the network.

Solution: Proxy re-encryption based DRM architecture.

Outcome: Prototype.

Project: dChat - CCN Chat for Android/Darpa/mobile devices

Industry: Government - DARPA

Problem: Warfighters rely heavily on chat for communication. This chat is an irc style service where people can chat on multiple channels with different sets of team members. Some chats are small (2-4 participants) and some are large (100+). Chat happens through centralized servers and fails when parts of the network are disconnected.

Solution: Create a distributed chat application with memory. Any node can join the chat if they have the right credentials. Chat messages synchronize between participants. If a node or nodes disconnect, they will synchronize back up when they reconnect.

Outcome: DEMO — We built a demo that we showed to DARPA and potential clients. It was also featured in an interview by Robert Scoble. http://www.youtube.com/watch?v=G0fJd9jpjdE

Project: Resolv

Industry: Government - DARPA

Problem: DARPA was looking for proposals for CBMEN (Content-Based Mobile Edge Network). Soliders in the field exchange data frequently and their communication can't depend on centralized servers. DARPA was looking for an ICN solution.

Solution: Resolv developed a ad-hoc ICN system based on CCN. Nodes would run CCN as the transport protocol and would provide a large set of features from support libraries. Resolv integrated network management, routing (via sync), automatic naming (via context) and an application services framework.

Outcome: Proposal — Our solution was not picked as one of the awards. We have used some of the concepts developed for Resolv as design principles for CCN services.

Project: NEPI Network Experimental Programming Interface

Industry: Academia (INRIA, France)

Problem: Need for a tool that helps in easier experimentation.

Solution: NEPI, a tool that supports easy description of network experiments, deploying on target environment such as testbeds or emulators, control resources, collect results generated.

Outcome: Conducted CCN experiments on PlanetLab to analyze various forwarding strategies.

Project: CCN chat with archival capability

Industry: Services

Problem: Chat application could not archive conversations, offline participants don't have access to chat history.

Solution: Developed a CCN-chat application that works in conjunction with a repo; conversations can be stored in the repo and chat history can be shared with new participants as well as offline participants when they come online.

Outcome: Architecture, design and implementation demonstration.

Project: VICS Verifiable Intelligent Cloud Security

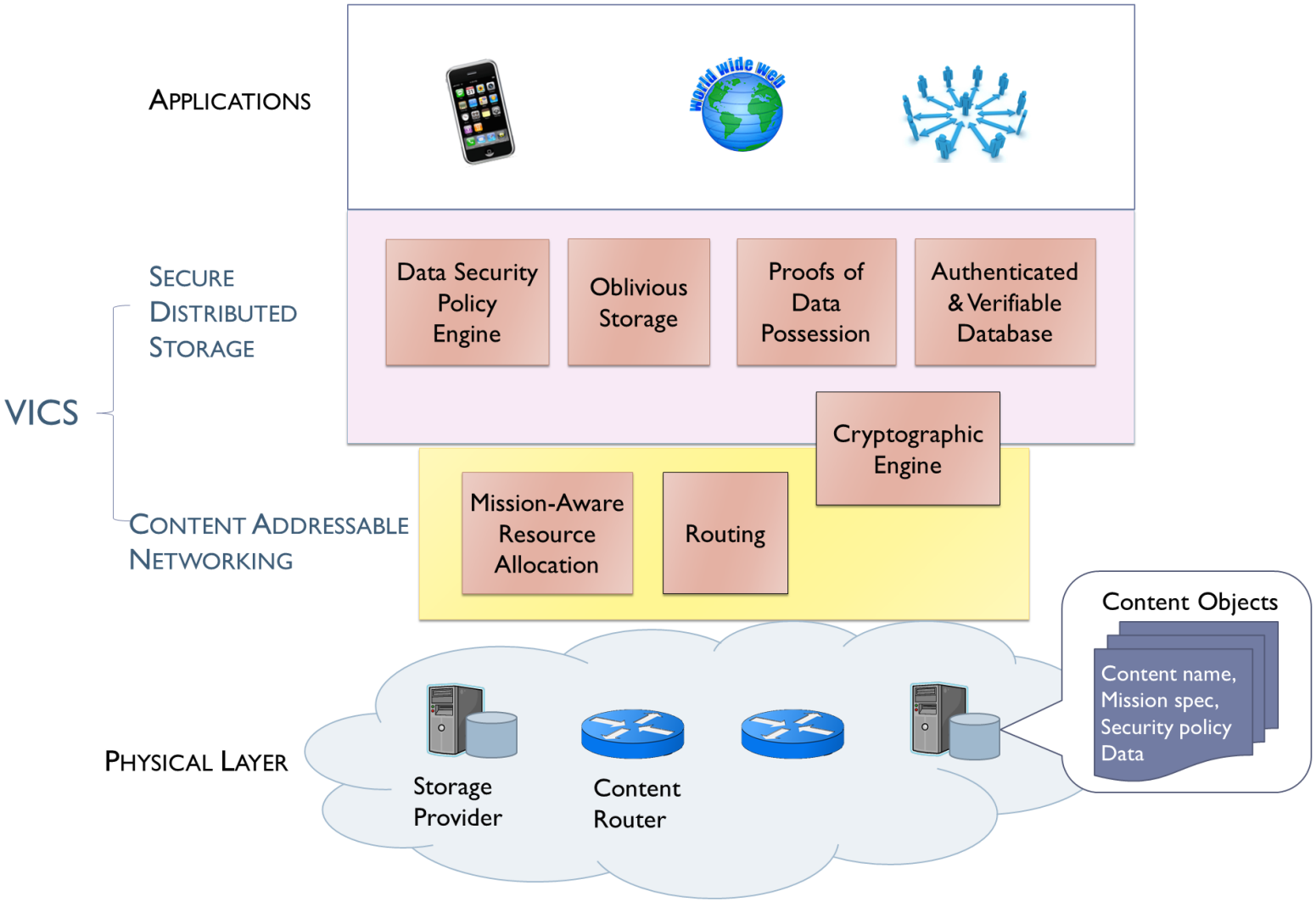
Industry: Government (DARPA)

Problem: Security concerns with today's cloud solutions such as inability to verify that user data has not been tampered with.

Solution: Secure, distributed data storage for the cloud and a resilient communication protocol that supports efficient mission-aware distribution of cloud data with fault-tolerance guarantees.

Outcome: Architecture and proposal.

Project: VICS Verifiable Intelligent Cloud Security



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Project: ONL Open Network Laboratory

Industry: Academia (WUSTL)

Problem: Obtaining and configuring machines for network experiments is difficult. Provide an environment for configurable and repeatable experimentation.

Solution: CCNx available on ONL. From website: The Open Network Laboratory is a resource for the networking research and educational communities, designed to enable experimental evaluation of advanced networking concepts in a realistic working environment.

Outcome: Publication and available for use.

https://onl.wustl.edu/public/Ancs08.pdf

https://onl.wustl.edu

Project: V-NDN Vehicular Named-Data Network

Industry: Academia (UCLA and UPMC), Services (Toyota ITC)

Problem: Cars are increasingly becoming networked, but they are still reliant on cellular + centralized communication.

Solution: Replace communication based on IP with NDN to allow vehicles and vehicle components to communicate over any medium/interface available.

Outcome: Poster at HotMobile 2013.

http://named-data.net/publications/13mc2r-poster/

Project: V-NDN Vehicular Named-Data Network

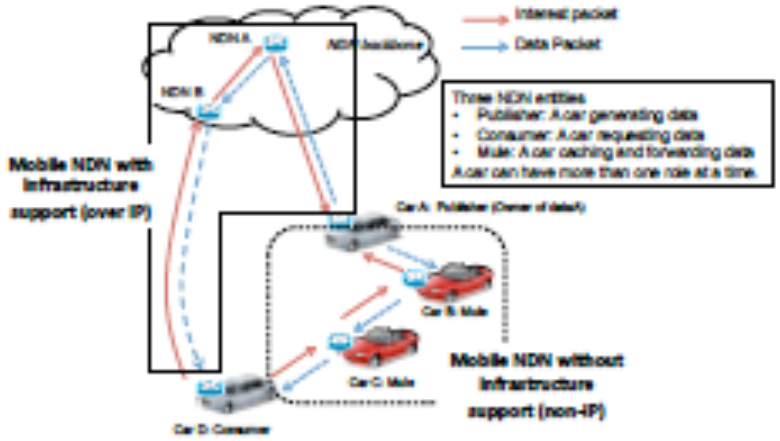

Figure 1: V-NDN Vehicular Named-Data Network : supporting infrastructure and -less networks

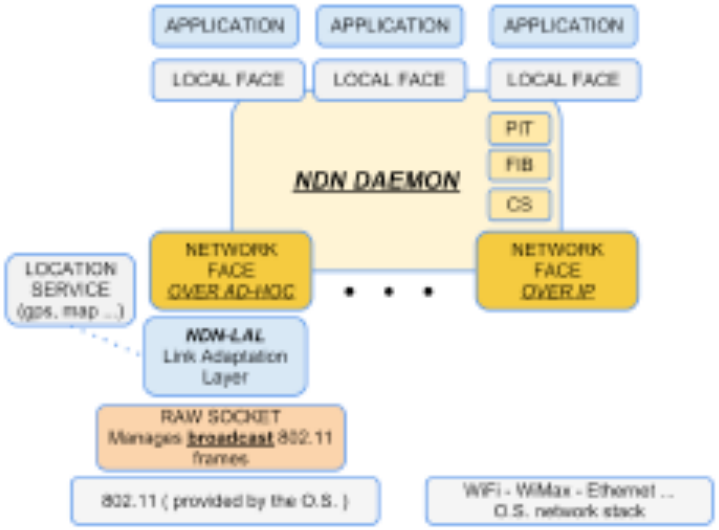

Figure 2: V-NDN logical architecture.

V-NDN

Project: javascript lib + cross platform browser plugin

Industry: Academia

Problem: Provide JavaScript implementation of CCNx that allows browsers to interact with a NDN network without installing CCNx.

Solution: Implement client library and wire format compatible with CCNx.

Outcome: Publication NOMEN 2013 and code available on github

www.cs.ucla.edu/~lixia/papers/NOMEN13-ndnjs.pdf

https://github.com/named-data/ndn-js

Project: javascript lib + cross platform browser plugin

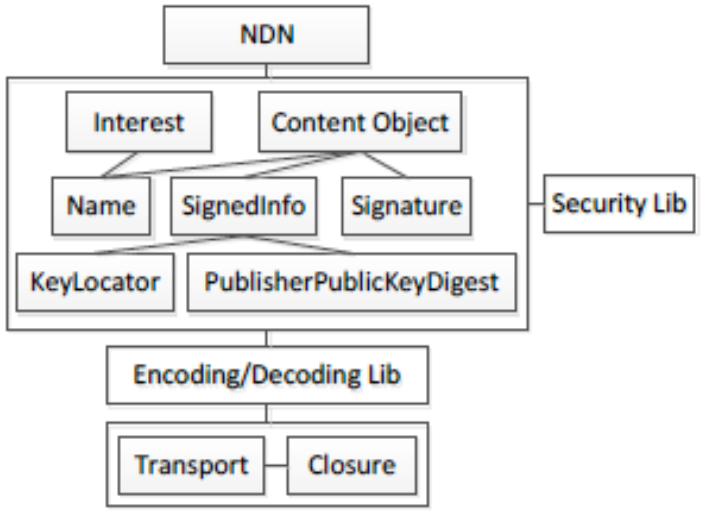

Fig. 1. NDN.JS library architecture

TABLE I
TESTED BROWSER SUPPORT OF NDN.JS

Brower	Version	Test Platform
Chrome	23.0	Windows / MacOSX
Firefox	17.0.1	Windows / MacOSX
Safari	6.0.2	MacOSX
Internet Explorer	10.0	Windows
Firefox Mobile	17.0	Android
Safari Mobile	6.0.1	iOS

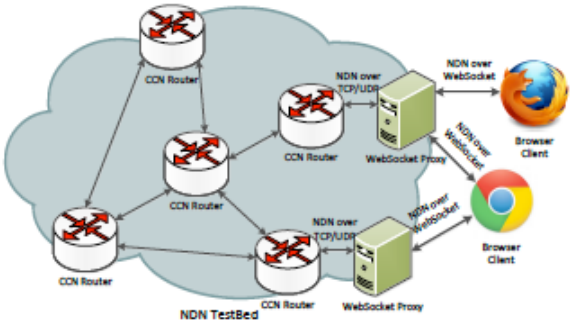

Fig. 2. WebSocket proxies connecting browsers to the NDN testbed

TABLE III
PERFORMANCE IMPACT OF CONTENT VERIFICATION IN NDN.JS

Browser Type	Throughput (Mbps) with Verification Disabled	Throughput (Mbps) with Verification Enabled
Chrome	46.01	10.15
Firefox	48.66	2.313
Safari	65.66	3.319

TABLE II
THROUGHPUT TEST RESULTS (UNIT: MBPS)

File Size	NDN.JS (WebSocket)			Native HTTP (XHR)			ccncatchunks2 (C utility)
	Chrome	Firefox	Safari	Chrome	Firefox	Safari	
742 KB	46.01	48.66	65.66	83.6	84.73	82.51	71.22
28.7 MB	62.26	71.07	74.75	88.71	89.33	89.02	75.41

NDN.js

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Project: Personal Data Cloud

Industry: Academia

Problem: An NDN ‘tranducer’ for personal data. Runs on Android phones as well as server.”

Solution: Implementation on github.

Outcome: Available on github:

https://github.com/gdrane/Ohmage_Phone

https://github.com/gdrane/Ohmage_Server_2

Project: Cisco Hardware Demo

Industry: Network Equipment

Problem: Is it feasible to forward CCN traffic based on names with current hardware? Specifically, what's the performance that can be expected out of a CISCO ASR 9000.

Solution: A ASR 9000 was programmed to forward CCN traffic using name hashing. A number of techniques were required to perform fast FIB lookups. Realistic traffic traces where used and heuristics were applied when looking at name components.

Outcome: The ASR 9000 was able to forward CCN traffic at 20Gbps using software forwarding running on intel architecture. The system handled attacks by having a worst case performance guarantee.

Project: Alcatel-Lucent Hardware Demo

Industry: Network Equipment

Problem: Is it feasible to forward CCN traffic based on names with current hardware? Is it possible to take advantage of GPUs and internal line card processing power?

Solution: Using a distributed method inside a router ALU was able to forward traffic through their routers, allowing each line card to process part of the name. GPUs were also a possibility taking advantage of their compute power to process interests and content objects through name hashing.

Outcome: A demo was completed showing 40Gbps CCN forwarding using an extra field to index components into the name structure.

Project: Mini-CCNx

Industry: Academia

Problem: As CCN becomes widely known and increases in popularity people want to use it for various scenarios. Some of these scenarios are too expensive to build or to complex to set up. For this reason emulators and simulators are needed for testing.

Solution: Create an emulation tool to evaluate the performance of CCN in complex topologies. Use the standard CCN codebase to test actual features and connect to real applications.

Outcome: Mini-CCNx is a tool for agile prototyping of Information Centric Networks (ICN) based on the Content-Centric Network (CCN) model

Project: Contextualized Information Centric Bus

Industry: Network Equipment

Problem: Find a way to allow policy and context-based interaction between producers and consumers of information.

Solution: CIBUS (Contextualized Information Centric Bus) is a communication framework between producers and consumers that allows entities to discover, publish and subscribe to resources based on context.

Outcome: Huawei created a demo using Raspberry Pis and laptop for a home network.