



BITS Pilani
Pilani Campus

Advance Computer Networks (CS G525)

Virendra S Shekhawat
Department of Computer Science and Information Systems



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Lecture: 5-6 [17-20 Aug 2018]

Agenda



- Future Internet Architecture Design Projects
 - Compulsory Reading
 - A Survey of the Research on Future Internet Architectures [Jianli Pan 2011]

Enough Patchwork for Internet...?



- Original simplicity is changing ...
 - Hourglass approach
- Why...?
 - New class of applications
 - Real time, multimedia, content distribution, 3D immersive, cloud services etc.
 - Operational and management requirements
 - Variety of business models
 - Security mechanisms
 - Firewalls, NAT (to come up from IPv4 address crunch!)
 - Scalability enablers gives rise to Adhoc solutions
- Patching can affect the performance ...

Problems with Current Internet [1]

- **Security**
 - Control, Management and Data planes are intermixed
 - Control messages are piggybacked with data packets
- **Mobility**
 - Identity and location in one (IP Address) makes mobility complex
- **Energy**
 - Assumes live and awake end systems
 - Communication can happen only when both ends are awake
- **No Explicit Support for Client-Server Traffic and Distributed Services**
 - e.g. connecting to Google

Problems with Current Internet [2]

- **One to one communication**
 - No support for multicast and multipath
- **Symmetric protocols**
 - No difference between a PDA and a big server
- **Stateless**
 - QoS is difficult
 - Some applications require guarantee about the delay and throughput of their flows
- **Location Independent Addressing**
 - Most services requires nearest server

Leading to New Internet Architecture



- Innovations in various aspects of the Internet
 - Security, mobility, energy, QoS etc.
- Collaborative projects putting multiple innovations into an overall networking architecture
- Testbeds for real-scale experimentation

Key Research Topics for Future Internet Design [.1]



- **Content or data oriented paradigms**
 - **Motivation**: Primary usage of today's Internet has changed from host-to-host communication to **content distribution**
 - **Challenges**: Data and content security and privacy, scalability of naming and aggregation, compatibility and co-working with IP
- **Mobility and ubiquitous access to networks**
 - **Motivation**: Shift from PC-based computing to mobile computing.
 - **Challenges**: Trade-off with **mobility and scalability, security, and privacy protection** of mobile users, mobile endpoint **resource usage optimization**

Key Research Topics for Future Internet Design [..2]



- **Cloud computing centric architectures**
 - **Motivation**: Computing becomes Utility Computing
 - **Challenges**: Needs to create secure, trustworthy, extensible, and robust architecture to interconnect **data**, **control**, and **management** planes of data centers
- **Security**
 - **Motivation**: In current Internet Security works as an Overlay not an integral part of it
 - **Challenges**:
 - **Technical aspects** → encryption, authentication, authorization
 - **Non-Technical aspects** → to provide trustworthy interface among the participants

Key Research Topics for Future Internet Design [...3]



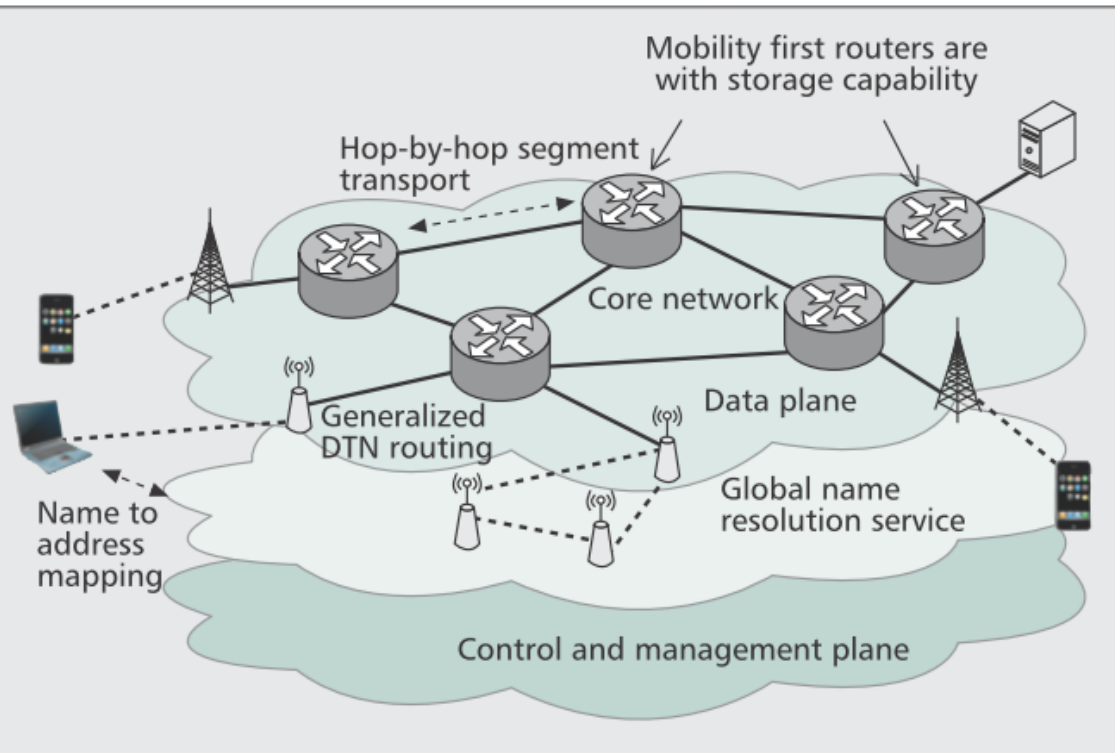
- **Experimental test beds**
 - Explore challenges related to large-scale hardware, software, distributed system test and maintenance, security and robustness, coordination, openness, and extensibility.

Research Projects on Future Internet Design



- **US National Foundation (2005)**
 - Working on project Future INternet Design (FIND)
 - *More info: www.nets-find.net/*
- **European Union**
 - 7th Framework program
- **Future Internet Architecture (FIA) (2010)**
 - NDN, NEBULA, Mobility First, XIA (Project collaboration)
 - *More info: www.nets-fia.net/*
- **Global Environment For Network Innovations (GENI)**
 - To provide a global large-scale experimental test-bed for future Internet architecture test and validation.

Mobility First Project (Rutgers Univ.)

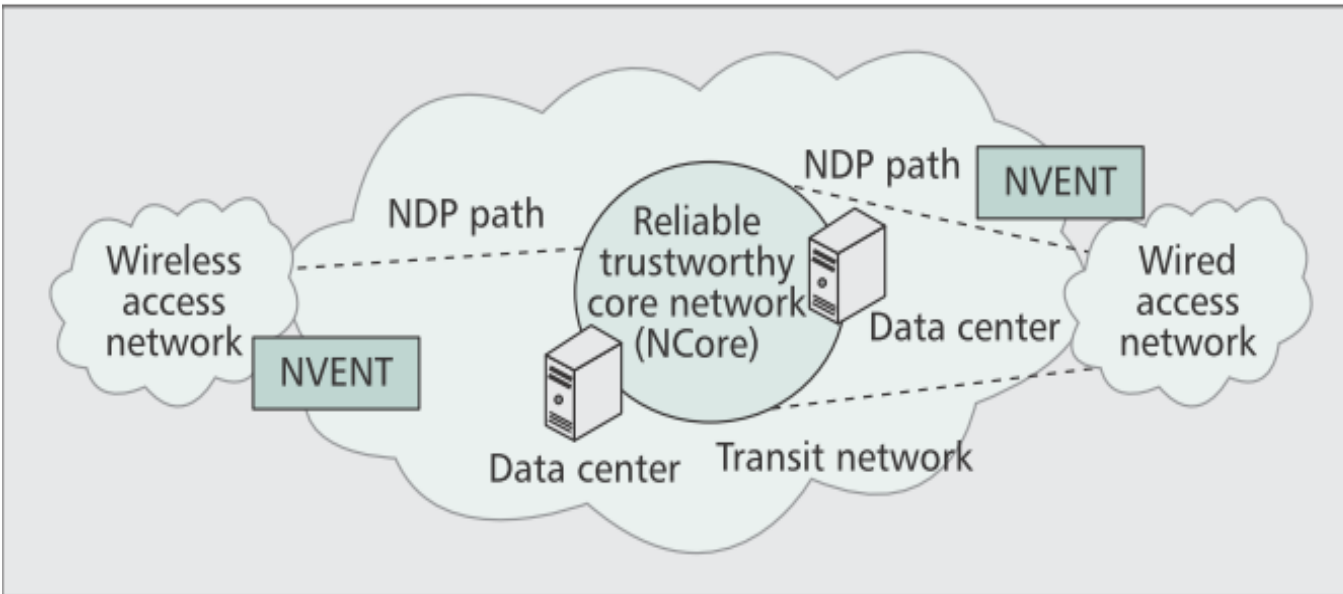


Challenges addressed by Mobility First

- Stronger security and trust requirements due to open wireless access
- Dynamic association, privacy concerns, and greater chance of network failure
- Content caching

Source: A Survey of the Research on Future Internet Architectures [Pan 2011]

NEBULA Architecture



Source: A Survey of the Research on Future Internet Architectures [Pan 2012]

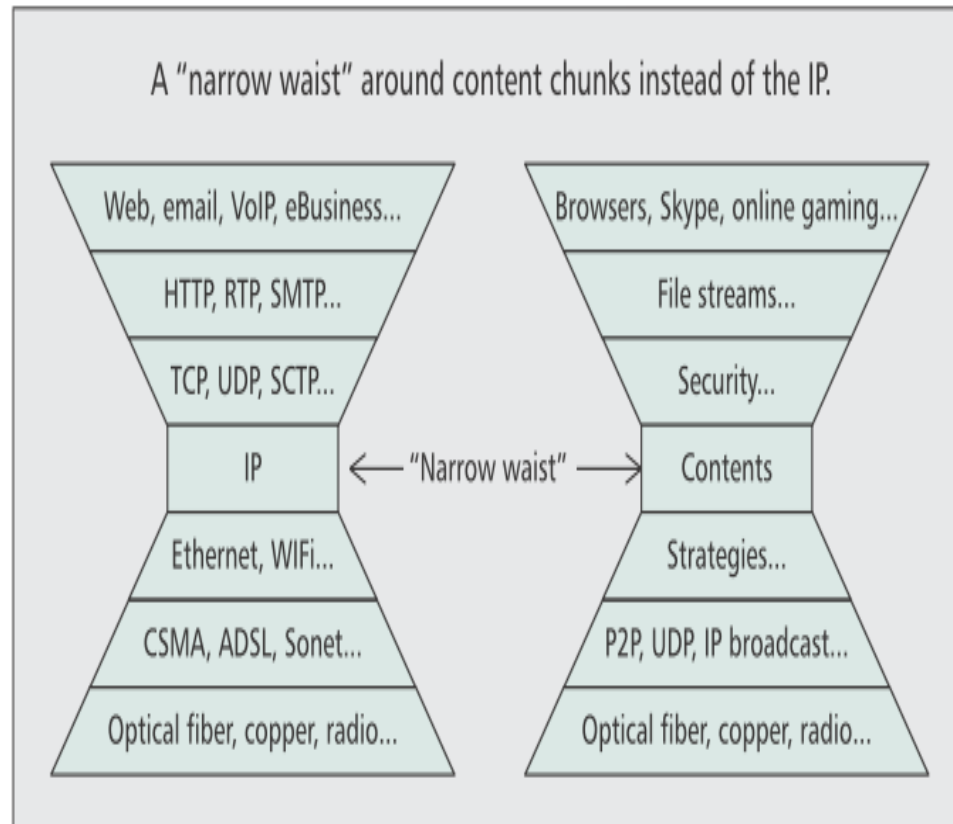
- Secure and high speed interconnection of Datacenters with parallel paths
- NDP-NEBULA Data Plane → Establishes trustworthy paths among routers and provides **policy compliant** paths
- NVENT- Extensible Control Plane to provide **application selectable service**
- NCore- Redundantly connected High availability routers (Interconnecting DCs)

Named Data Networking Project (Univ of California)



- Moving from end to end packet delivery to Content Centric Model
 - Current client server model facing challenges in supporting **secure content oriented** functionality
 - Network is transparent and just forwarding the data
 - NDN focuses on ‘what’ (content) in place of ‘where’ (address)
 - Allows **content caching** on network side to optimize the traffic

Architectural Principles of NDN: Key Points



Next...



- **NDN Architecture Details**
 - Compulsory Reading
 - NDN Project Technical Report [L Zhang 2010]
 - Additional Reading for ndnSim
 - named-data.net/techreport/TR005-ndnsim.pdf

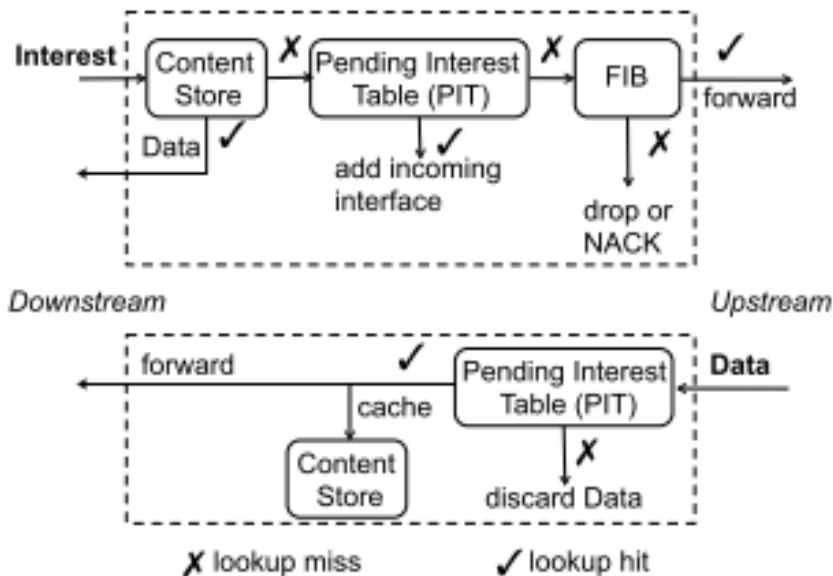
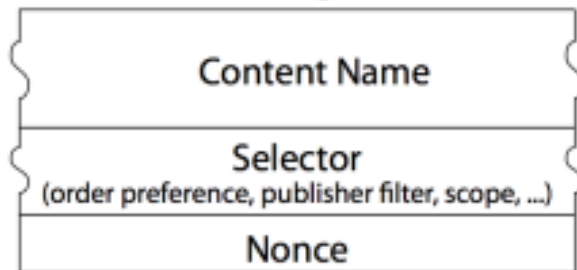
NDN Architecture [1]

- **Communication is driven by the receiver (consumer)**
 - Sends interest packet
 - e.g. /pilani/computerscience/courses/acn/lectures/lec1.pdf
- Router forwards **Interest packet** by looking up the name in its **FIB** (name based routing protocol)
- **Data packet** travels on the same path followed by the **Interest packet** in reverse direction
 - It carries both the name and the content of the data, together with a signature by the producer's key

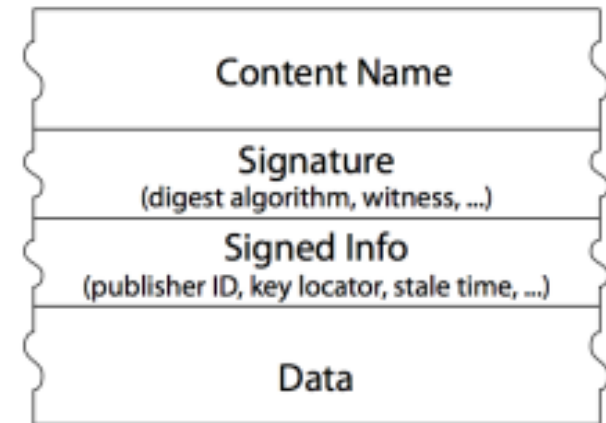
NDN Architecture: Forwarding Process



Interest packet



Data packet



NDN Architecture [2]

- NDN Supports following inherently
 - **Content Distribution** (many users are requesting the same data at different times)
 - **Multicast** (Many users are requesting same data at same time)
 - **Mobility** (users requesting data from different locations)
 - **Delay Tolerant Networking** (Users having intermittent connectivity)

Data Names

- How to find the data, or how the data are named and organized to ensure fast data lookup and delivery...?
 - Hierarchically structured names
 - /pilani/computerscience/courses/acn/lectures/lec1.mp4/1/2
 - Names are application specific and opaque to the network
 - Dynamic data can be retrieved by common agreement between consumer and producer
 - Not all the names need to be *globally unique*
 - Name space management is not part of the NDN architecture, just as in IP networks

Data Centric Security

- NDN proposes to secure the data directly instead of securing the data “containers” such as files, hosts, and network connections.
- Each piece of data is signed (mandatory) together with its name, securely binding them.
- Trust of Host and servers → Trust in Data
- NDN’s data-centric security can be extended to content access control and infrastructure security.

Routing & Forwarding...[1]

- **Forwarding**
 - Forwarding is based on names
 - Is there any benefit wrt IP Routing...?
- **Routing**
 - IP Prefixes → Name Prefixes
 - Existing routing protocols can be used to construct FIB table
- **Question..?**
 - How to keep routing table sizes scalable for unbounded data names
 - NDN names are longer than IP addresses, but the hierarchical structure helps the efficiency of lookup and global accessibility of the data.

Routing & Forwarding...[2]

- **NDN Inherently supports multipath routing**
 - No chance of looping like IP routing... Why?
- **It improves Routing security...How?**
 - Every data is signed...including routing messages
 - Multipath routing mitigates prefix hijacking because routers may detect the anomaly caused by prefix hijacking and try other paths to retrieve the data.
 - Attacking to a particular target is difficult... Why??
- **Privacy Protection**
 - No information about who requested what data

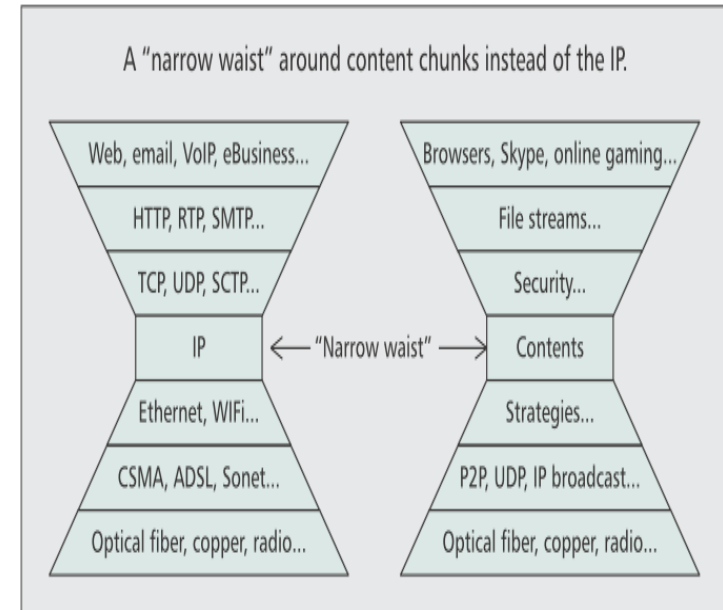
No Transport Layer in NDN

- Transport Layer functions can be placed either in the application or NDN layer
 - Multiplexing and demultiplexing among application processes is done directly using names at the NDN layer
 - Data integrity and reliability are directly handled by application processes
 - NDN routers manage traffic load through managing the Interest forwarding rate on a hop-by-hop basis
 - NDN eliminates the dependency on end hosts to perform congestion control

Architectural Principles of NDN: Key Points



- **Hourglass architecture** is maintained surrounding the Data NOT IP
- Security is built-in into the architecture itself
- **Retains the E2E** for fast application development and caters network failures.
- **Flow balanced data delivery** ensures self regulating network traffic
- **Routing** and **Forwarding** planes separation
- Caters **user choice** and competition where ever possible



NDN Key Research Areas Evolved



- Development of NDN Applications
- Data Namespaces
 - e.g., Name Discovery, Name design
- Trust Models
- Routing and Forwarding Mechanisms
 - Forwarding Strategy Design (e.g., better path selection)
 - Forwarding Engine Design (e.g., fast lookup, efficient storage)
 - Routing Protocol Design (e.g., NLSR)
- In Network Storage
- Data Synchronization

Resources



- NDN Project URL
 - <https://named-data.net/>

Thank You!