Introduction: The Internet and its Future

MobilityFirst Workshop

Organized as a part of:
Project: Engaging undergraduates in research that speaks their language
Sponsoring Agency: The Thurgood Marshall College Fund
Sponsoring program: Undergraduate Research to Retain and Graduate Students in STEAM

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Overview

1. Internet Architecture
2. Future Internet Architecture
3. Workshop focus and roadmap

What is the Internet

On October 24, 1995, the Federal National Council (FNC) unanimously passed a resolution defining the term Internet.
"The Federal Networking Council (FNC) agrees that the following language reflects our definition of the term "Internet"[1]

"Internet" refers to the global information system that –

1. is logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions/follow-ons;
2. is able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/follow-ons, and/or other IP-compatible protocols; and
3. provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein."

[1] http://www.nitrd.gov/fnc/Internet_res.aspx

How does the Internet look like?

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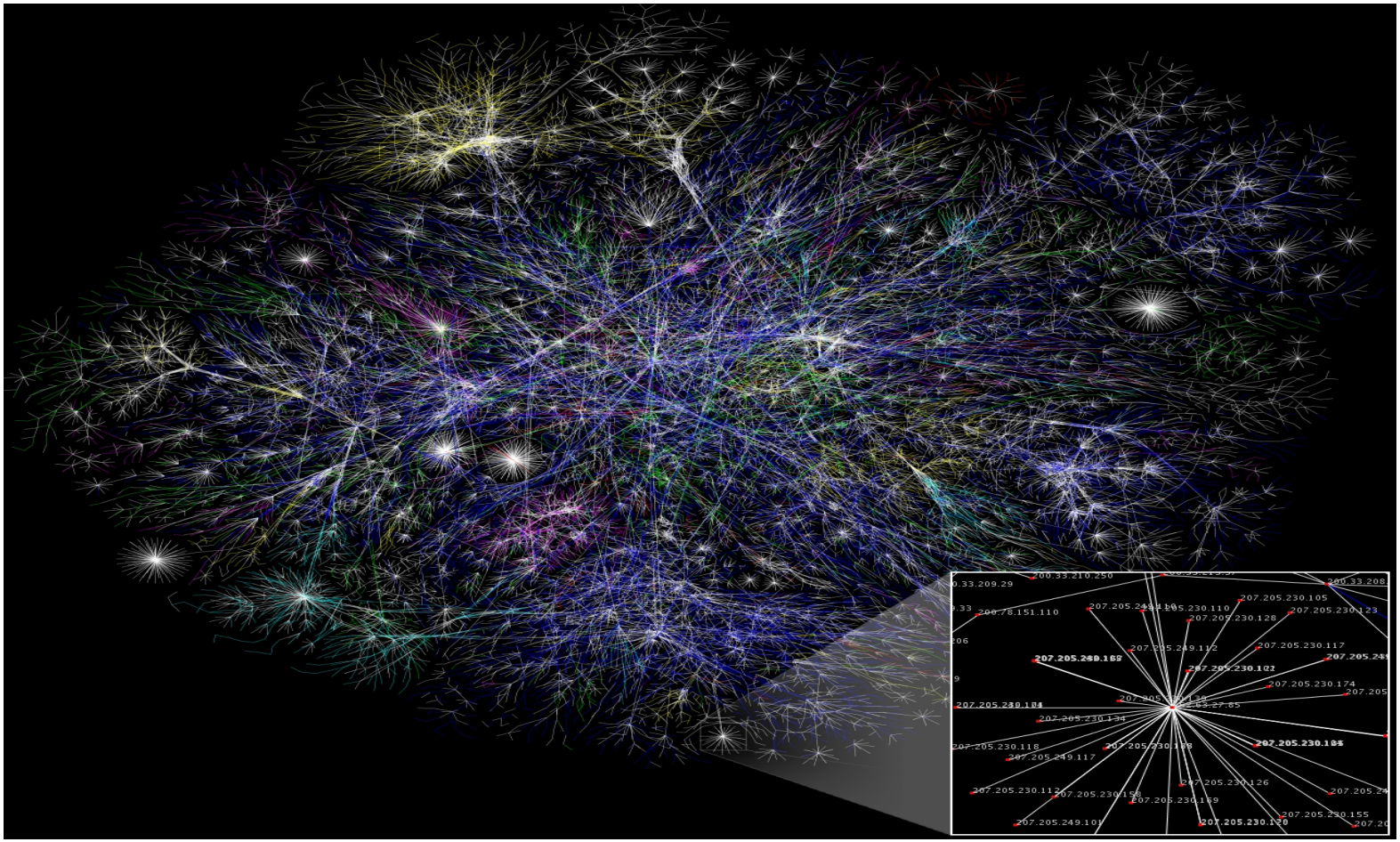

Figure : Map of the Internet[2]

[2] http://en.wikipedia.org/wiki/File:Internet_map_1024.jpg

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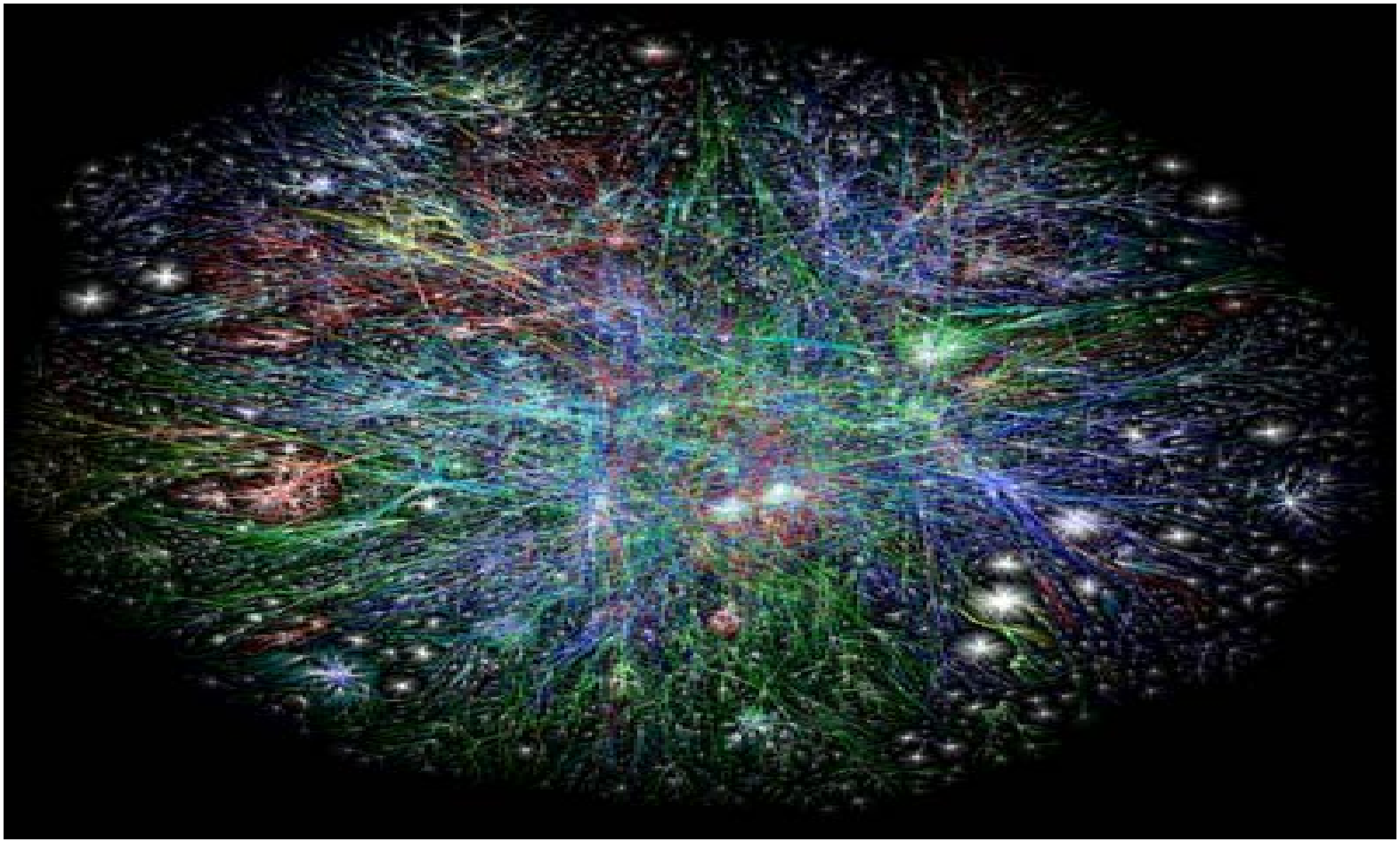

Figure : Map of the Internet[3]

[3] http://www.huffingtonpost.com/grant-cardone/creating-an-internet-pres_b_642086.html

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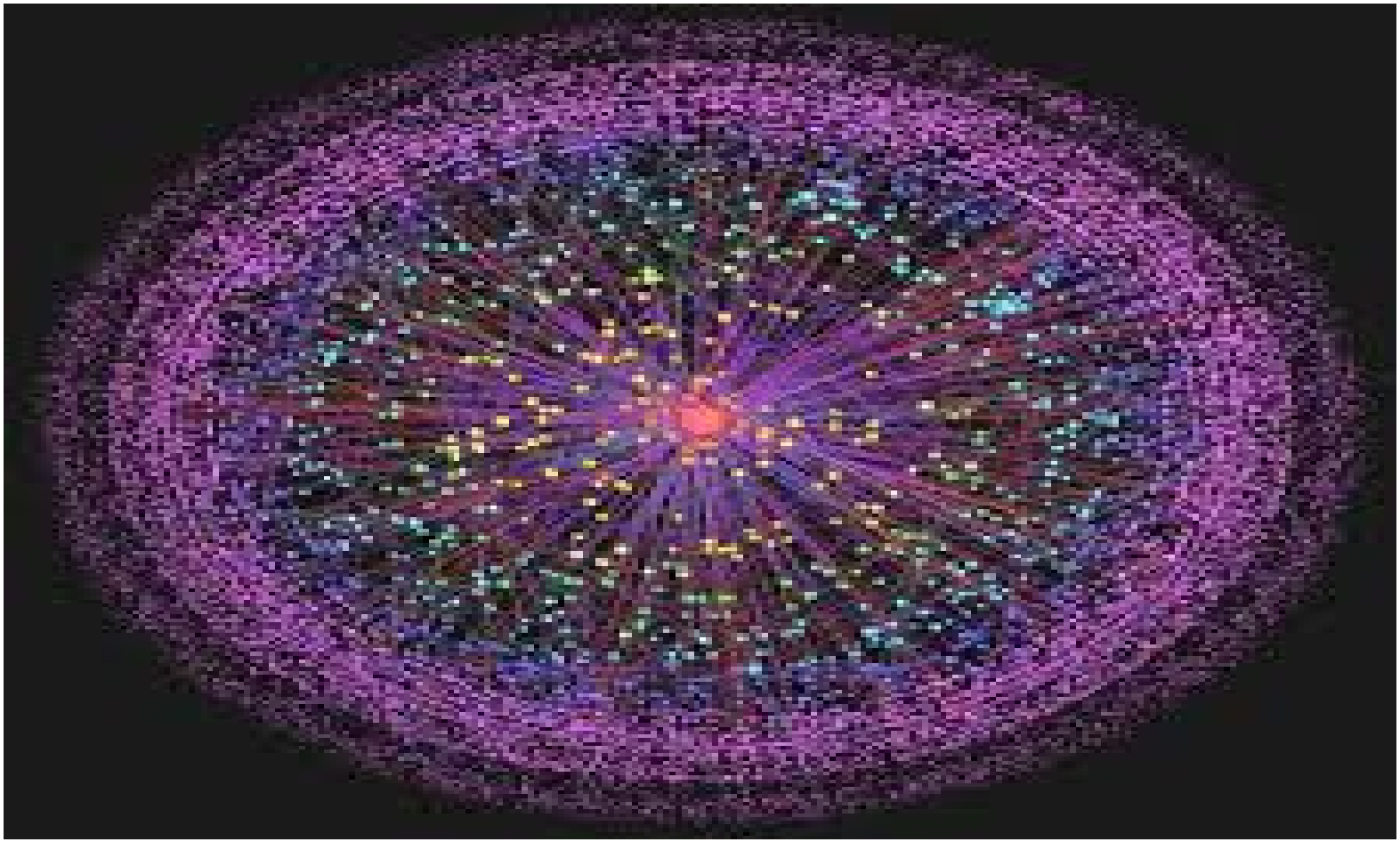

Figure : A Model of the Internet[4]

[4] "A model of Internet topology using k-shell decomposition", Carmi, Shai et al. (2007) Proc. Natl. Acad. Sci. USA 104, 11150-11

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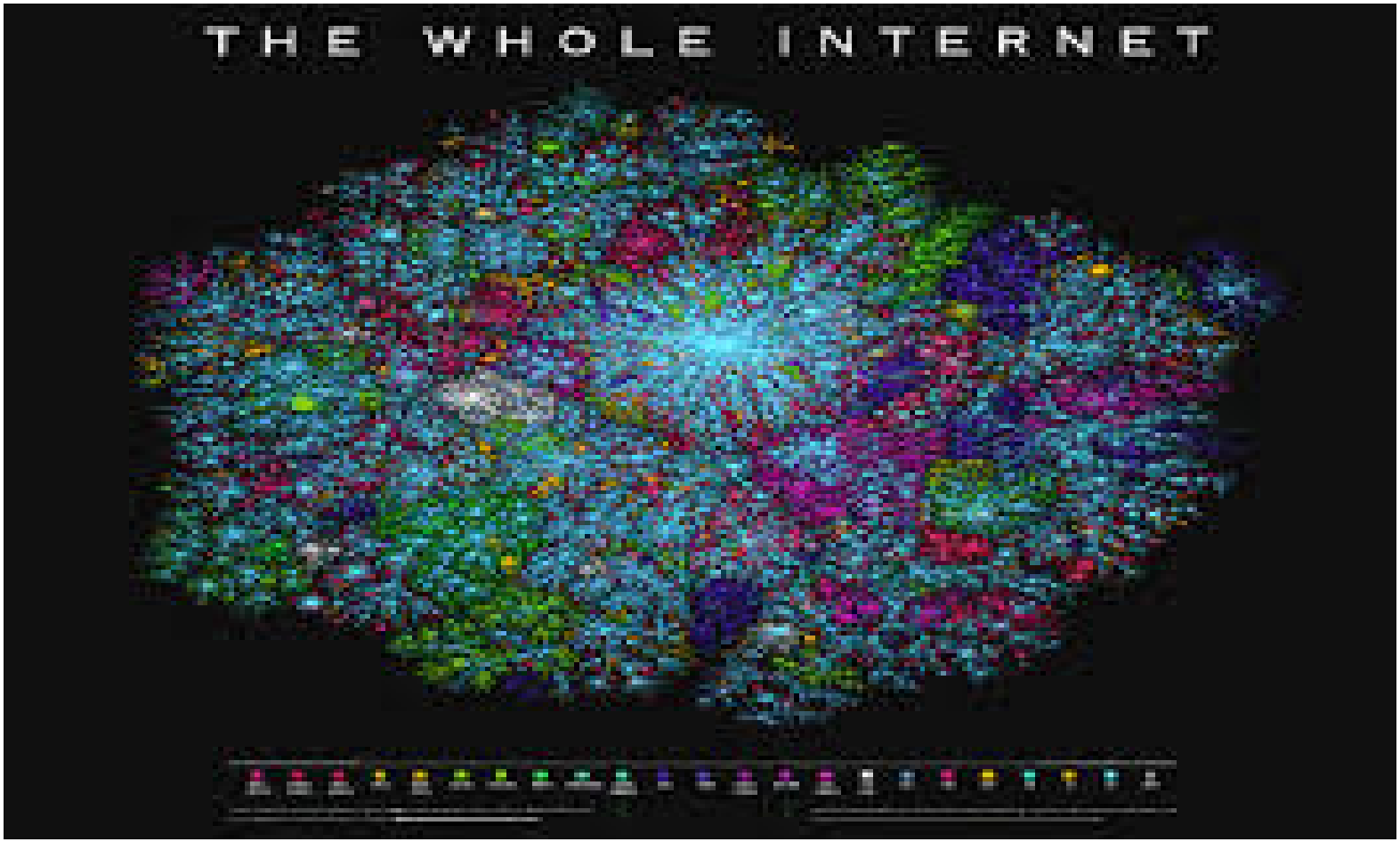

Figure : The Whole Internet[5]

[5] http://www.unc.edu/~unclng/Internet_History.htm

Ok, So how does the Internet contain?

Hardware

- cables: optical fibers, coaxial cables, twisted pair cables, Ethernet cables
- switches, routers
- computers, servers, phones, tablets

Software

- Device drivers
- Internet Protocol
- TCP, UDP
- DNS, Web browsers, Communication application clients and servers,

Can you give me a more technical picture?

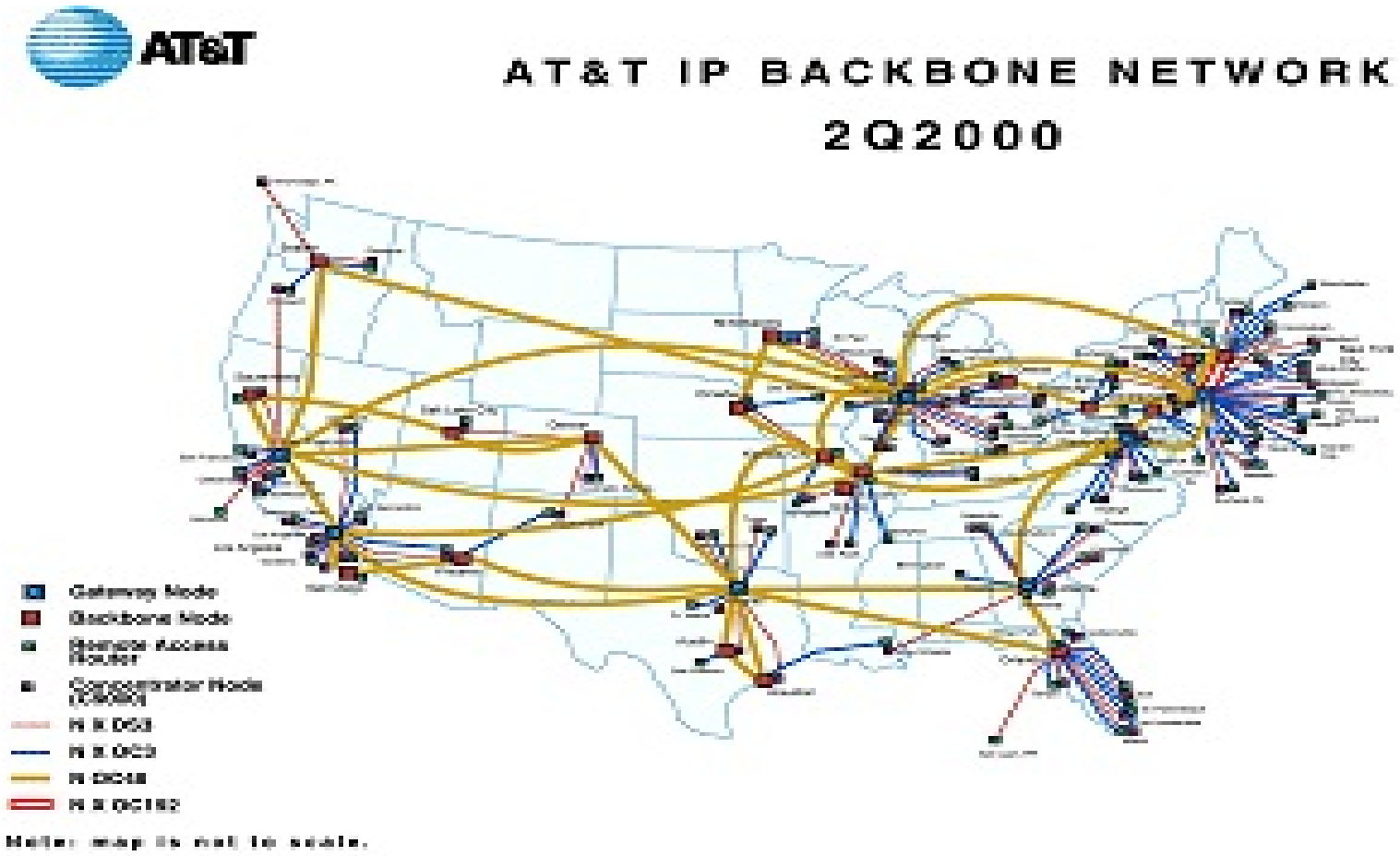

Figure : AT&T's Backbone network as of year 2000 - Tier 1 ISP

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[6] http://personalpages.manchester.ac.uk/staff/m.dodge/cybergeography/

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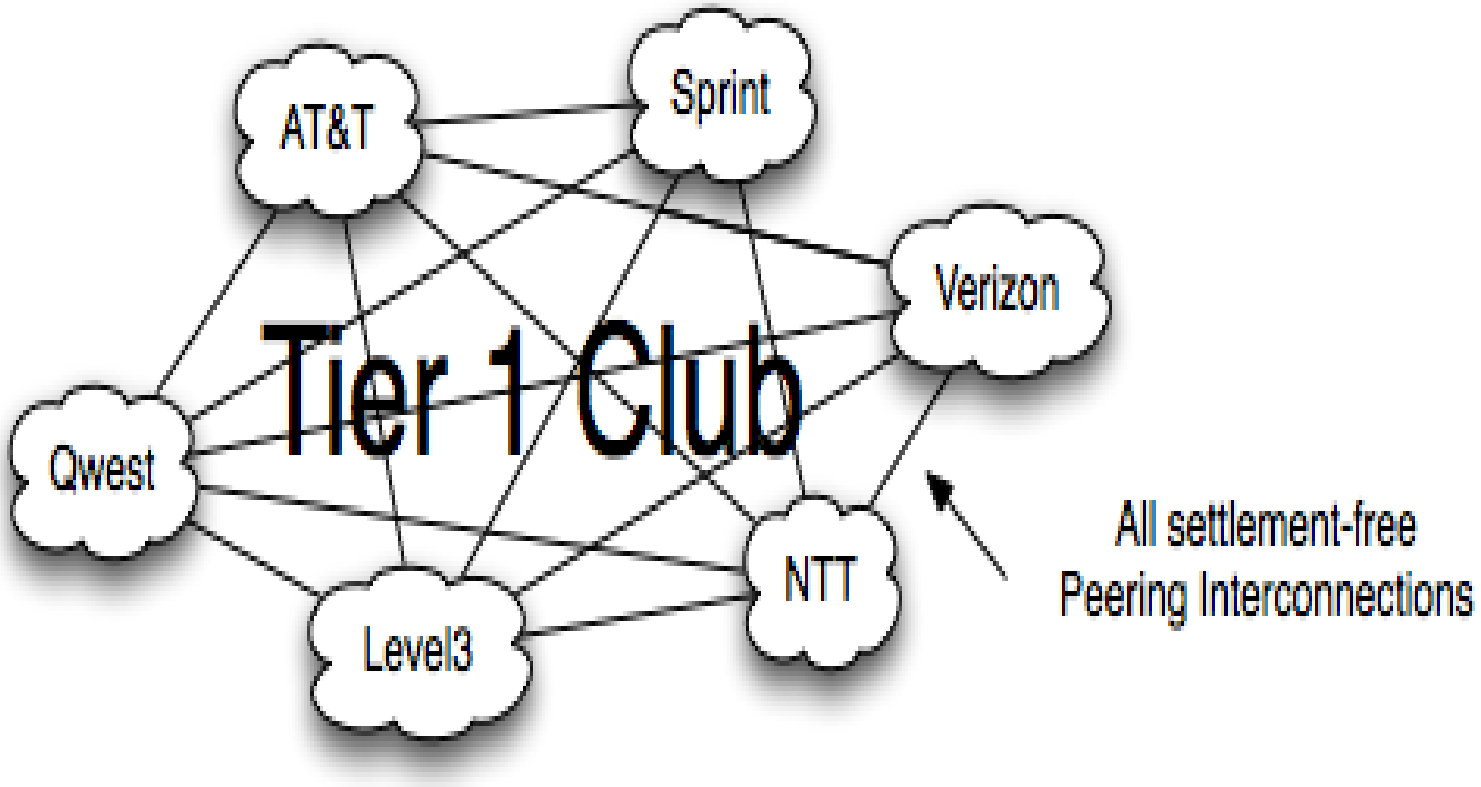

Figure : Connections between all Tier 1 ISPs

[7]

[7] http://drpeering.net/white-papers/Ecosystems/Tier-1-ISP.html

Can you give me a more technical picture?

- Tier 1 ISPs maintain the backbone networks which is essentially connecting different regional offices with optical fibers. These are the transit networks
- Tier 2 ISPs buy transit bandwidth from Tier 1 ISPs to send data from one region to another
- Tier 3 ISPs buy transit bandwidth from Tier 2 ISPs and provide connectivity to the public and to send data within the region

Can you give me a more technical picture?

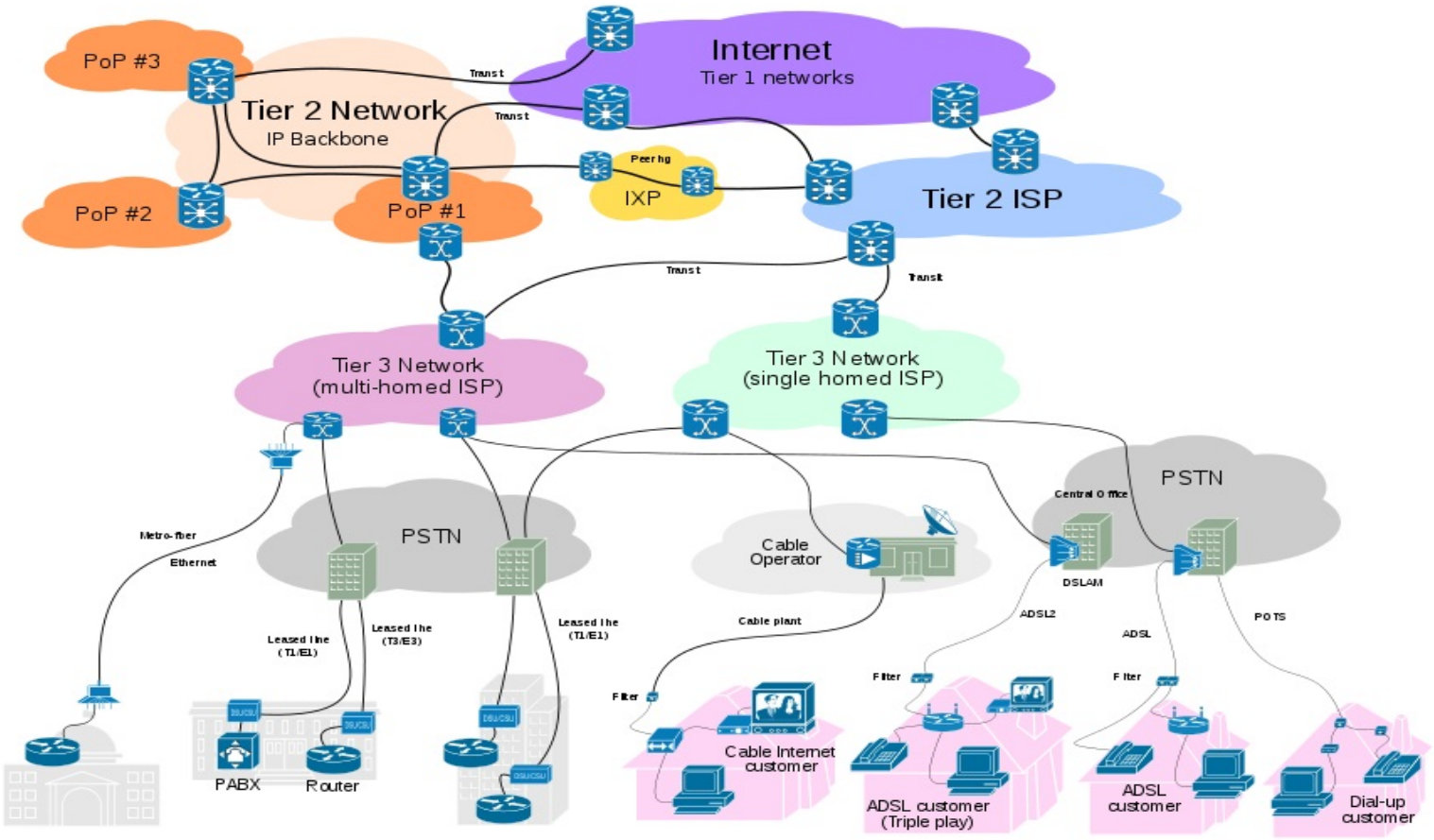

Figure : Overview of Internet connectivity [8]

[8] http://en.wikipedia.org/wiki/User:Ludovic.ferre

Getting more technical

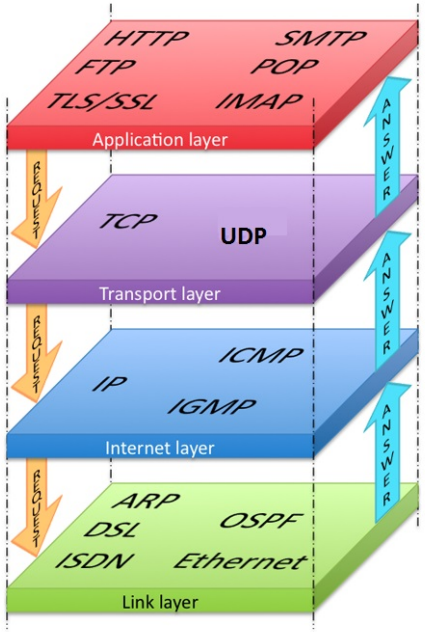

Figure : Internet Protocol Stack[9]

Functionalities that enable devices to communicate in the network are categorized and organized as a protocol stack

[9] http://named-data.net/project/execsummary/

Getting more technical

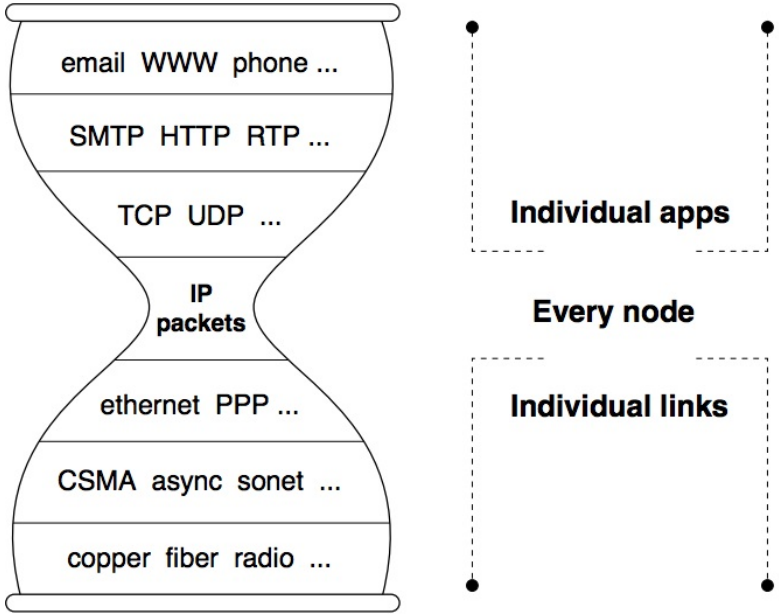

Figure : Hourglass Architecture of the Internet[10]

There is one and only one IP layer but...

Lots of ways to do things above and below IP

[10] http://named-data.net/project/execsummary/

Role of IP

- Addressing mechanism for devices (like home/office addresses) that enables two devices to find each other and communicate
- Good for communication between specific end points but not so good to find someone or something based on a classification, keyword or type.

Limitations of IP

Can I stream a movie?

- Suppose I really want to watch a movie, which might be available on more than one device (may be my neighbor Jenny's DVR has a copy!).
- IP cannot directly find these places, we need another mechanism (like Google search) to find them and then use IP to get the movie. (But Google search will not be able to find it from Jenny's DVR!)

Can I share my streaming video with my friend so we both watch on our tablets at the same time?

- Two people, no matter how close or far they are will need to stream their contents individually
- Each device will have its own connections to the streaming server
- Duplicate data will travel through the wires/pipes in the network to reach the same location

Limitations of IP

Can I find your location?

- IP addresses can be easily traced to a location
- Many applications and software use this information to locate people, to provide location enhanced service and then some more...

Can I pretend to be somewhere else and attach your servers?

- The source IP addresses can be easily spoofed (changed) so they cannot be traced back to the correct location
- Large scale denial of service attacks can be launched by taking over various resources and attacking key infrastructure

Future Internet Architecture Program

Sponsored by the National Science Foundation[11]

The Internet has created unprecedented opportunities for advancing knowledge across the spectrum of human endeavors. It has evolved from a small scale network of networks to become integral to our lives and vital to the operation of all critical sectors of our society. The continued success of the Internet, however, is increasingly threatened by the ever-mounting sophistication of security attacks and by the lack of performance reliability of Internet services. As our reliance on a secure and highly dependable information technology infrastructure continues to increase, it is no longer clear that emerging and future needs of our society can be met by the current trajectory of incremental changes to the current Internet.

[11] http://www.nets-fia.net/

Future Internet Architecture Program

Goal: Design secure and highly dependable information technology infrastructure

Research Objective: Engage the research community in collaborative, long-range, trans-formative thinking - unfettered by the constraints of today's networks yet inspired by lessons learned and promising new research ideas - to design and experiment with new network architectures and networking concepts that take into consideration the larger social, economic and legal issues that arise from the interplay between the Internet and society.

Steps Taken: In the summer of 2010, NSF funded four projects as a part of this program. A fifth project was subsequently funded under a different solicitation.

Future Internet Architecture Projects : Named Data Networking

Principal Investigator: Lixia Zhang, UCLA
Collaborating Institutions: Colorado State University, PARC, University of Arizona, University of Illinois/Urbana-Champaign, UC Irvine, University of Memphis, UC San Diego, Washington University, and Yale University

- Suggests to move the communication paradigm from today's focus on "where", i.e., addresses, servers, and hosts, to "what", i.e., the content that users and applications care about.
- By naming data instead of their location (IP address), NDN will transform data into first-class entities.
- NDN will develop the concept of trustworthiness of the data regardless of the source of data
- Will enable automatic caching to optimize bandwidth
- Will allow content to move along multiple paths to the destination

Future Internet Architecture Projects : MobilityFirst

Principal Investigator: Dipankar Raychaudhuri, Rutgers University/New Brunswick
Collaborating Institutions: Duke University, Massachusetts Institute of Technology, University of Massachusetts/Amherst, University of Massachusetts/Lowell, University of Michigan, University of Nebraska/Lincoln, University of North Carolina/Chapel Hill

- Project is centered on mobility as the norm, rather than the exception.
- Will use generalized delay-tolerant networking (GDTN) to provide robustness even in presence of link/network disconnections
- Self-certifying public key based addresses will provide an inherently trustworthy network
- Will allow functionalities like context–and location–aware services to fit naturally into the network.

Future Internet Architecture Projects: (NEBULA)

Principal Investigator: Jonathan Smith, University of Pennsylvania
Collaborating Institutions: Cornell University, Massachusetts Institute of Technology, Princeton University, Purdue University, Stanford University, Stevens Institute of Technology, University of California/Berkley, University of Delaware, University of Illinois/Urbana-Champaign, University of Texas, University of Washington

- Project promotes the Cloud Computing model
- All data storage and computation will be in data canters connected together by a high-speed, extremely reliable and secure backbone network
- Project focuses on developing new trustworthy data, control and core networking approaches to support the cloud computing model of always-available network services

Future Internet Architecture Projects : eXpressive Internet Architecture (XIA)

Principal Investigator: Peter Steenkiste, Carnegie Mellon University
Collaborating Institutions: Boston University, University of Wisconsin/Madison

- Identifies three communicating principals – hosts, content, and services
- Defines a narrow waist for each principal that dictates the application programming interface (API) for communication.
- Will provide intrinsic security in which the integrity and authenticity of communication is guaranteed

Future Internet Architecture Projects: ChoiceNet

Principal Investigator: Tilman Wolf, University of Massachusetts
Collaborating Institutions: University of Kentucky, North Carolina State University, RENCI/University of North Carolina

- Aims to use principles of economics to design an architecture that is based on choice
- Network will encourage alternatives to allow users to choose from a range of services
- Users will be allowed to vote with their wallet to reward superior and innovative services

Focus and roadmap of this Workshop

- Overview of three of the most active and in many ways related projects: NDN, MobilifyFirst and XIA (Week 2)
- Delve deeper into the MobilityFirst Project (Week 3-5)
- Explore the MobilityFirst software router and API (Week 6)
- Write a simple android application using the MobilityFirst API (Week 7 and 8)

Comments or Questions?