Networking Science and Engineering Breakout Report

Introduction

Vision for the network 20 years horizon is a complex socio-technical structure, with economical and policy integrated with the physical communications infrastructure. Future networks are complex, our challenge is how to tame the complexity to enable understanding and design. Aiming for simple design should be one of the approach goals.

User will have a natural and richer experience with the network that will encompass complex social, economic, policy related interactions. Users – or the sense that applications interact with the network – will be provided seamlessly and in a manner responsive to what the user/stakeholder desires.

The network will provide stakeholders at anywhere, anytime:

- Minimal cost
- Reliability
- Security, privacy
- Limited only by fundamental physical constraints
- Responsive to users (stakeholders) needs

Properties:

- Network will be complex in nature
- highly heterogeneous: devices, reliability, speed, channel characteristics, connectivity
- Conflicting interests
- Dynamic, evolving
- Scale
- Creating/enabling 'holistic' cyberinfrastructure of resources

Requirements:

- Reliability, availability, performance, etc.
- [security is extended beyond confidential, secret information to privacy and usability in envisioned networks] Security – privacy and usability – this is new because the network will incorporate law, policies, social, and economic tools – of multiple self-interest driven autonomous entities to enable sharing for legitimate endeavors, foster economic

Research Needs

1. Fundamental

Rethink the fundamentals of how we understand (model, simulate, analyze, measure), design, build, deploy, manage, monitor and evolve these envisioned future networks.

Need science to understand complex networks at different levels of granularities: models, abstraction, tools. The social, economic, and regulatory aspects need to be inherently integrated.

Understand the interplay between the different components of the complex structures

2. Architectural frameworks and design principles

Rethinking of the layering concept – explore whether the layering concept is fundamental, how might cross-layer approaches be incorporated. What other paradigms for modularity can be explored. How can virtualization at scale be inherently integrated in these architectural approach.

Hardware independent evolvable, extendible, architectures to allow for flexibility in the designs across multiple platforms

Explore uniform (universal) frameworks for virtualization at scale at different levels and for different resources

- Revisit design principles (fundamental to our current networks) End to end argument in light of socio-economic infrastructure context
- Explore new paradigms that can explore issues such as network neutrality in the new context of socio-economic infrastructure

Rethink, principles of naming and the tight coupling of paths addresses. Richer and secure name management system

Protocols at different levels that are aware and can address real time flows, mobility, dynamically changing environments, different channel characteristics.

Need to handle data intensive collection, storage, and dissemination – in multi-point to multi-point environment

Support of dynamic resource allocation at scale to incorporate traffic engineering

3. Management and control

New control and management paradigm, frameworks, and tools, that provide adequate interfaces and effectively integrate physical, logical, and human components and resources of the complex networking structure

New paradigms and frameworks, tools, to provide uniform interfaces for adequate management and control at different time granularities and topologies

4. Routing architectures

New computationally efficient, scalable, algorithms that allow planning, scheduling, resource allocation. Allow and enforce diverse policies for the multi-stakeholders.

Support security

Allow federation and inter-operability

5. Experimentation and Test-beds:

Collaborative research projects that can address scale and multi-disciplinary nature in depth and breadth and with different expertise

- Testbeds

We need to move beyond planetlab. How to make it more representative of the Internet, or of other environments? We need objective metrics for evaluating the efficacy of a testbed for a given experiment. Relating to real networks, e.g. enterprise networks, residential environments, network dynamics, traffic patterns. For things like Emulab, how did you configure it? What characteristics did you attempt to capture?

should address all major goals: telescope paradigm (depth) deployment paradigm (breadth, wider scale) things one can do on a testbed that you can't do on an operational network

- Design of experiments

Large experiments take a great deal of time and money (have high cost) and must be carefully planned and constructed. Can do them on testbeds, or on operational networks, in simulation. We need rigorous methods to design experiments, conducting them and evaluating the results.

Beyond links and routers, we need to include users. Human factors are critical for certain types of experiments. testbed environments should tap the user environment.

adequacy of instrumentation

leverage existing methods from other areas (statistics, combinatorial design)

relationship between simulation, testbeds

6. Research Priorities