

Towards solidifying a Science of the Internet: The Network Perspective



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Objective

- Networks: From cellular → to ad-hoc wireless (mobile) → to sensors → to Internet of things → to overlays → to cognitive radios,...
- to network virtualization → to decentralized Data Centers,...
- Create an **epistemic, solid, universal** theory for the federation of spontaneously interacting elements comprising the Future Internet
 - Unprecedented network complexity
 - Multi-scale operation, spatiotemporally unpredictability
 - Distill gigantic amount of data
- **Complexity** and how to manage it
 - In evolutionary, online fashion
 - Extract knowledge
 - Exploit it to decision making

Main Research challenges

- A first principles holistic framework for complex networks
 - How do macroscopic properties emerge out of microscopic scale random interactions?
- Understanding limits of self-reasoning and cognition
 - Decision making under uncertainty, statistical learning
 - Stochastic control, Optimal control
 - Wisdom of the crowds?
- **Self-management** of autonomic internet components
 - Self-optimization
 - Non-cooperative, cooperative games, resource trading
- **Prudence in energy consumption**
- Understand → characterize → predict → decide → optimize (and round and round again...)
 - extract knowledge from network
- Experimentation dimension

Impact & Plausibility

- Immense impact to society / economy
 - Access to information
 - Optimized end-to-end transport of information
 - automated network management
 - Accelerated, green computing, low ICT carbon footprint
 - Enabler for new applications/services not yet imagined
- Proof-of-concept & plausibility:
 - now possible through experimentation
 - Large-scale federated experimental facilities now a reality
 - Complementarity to FET and ICT Objective 1.x projects
 - And initiatives in USA (FIND, GENI), Asia (FIF), Australia,...

Need for Confederation of disciplines

- **Cognition Science**: how entities develop cognition and learn amidst uncertainty and limitations
 - Online estimation-detection, pattern recognition,..
- **Economics**: Internet to comprise a Resource Market
 - Pools of resources, auction theory,...
 - Game theory, market-based transactional theory,
- **Control theory**: Stochastic & optimal control
 - Network optimization
- **Network information theory**: value of information, fundamental performance limits
- **Evolutionary biology**
- **Statistical Mechanics / Physics**: microscopic interactions and microscopic behavior of particles
- **Experimentation in test-beds (proof of concept)**

Internet Science Flagship

- FLAGSHIP: A ship that carries a fleet's commander and the flag!
 - What's the fleet ?
 - What's the FLAG?
 - Keep the fleet together !
 - Raise the flag high so that other ships see !
 - Pave the way forward ... in the ocean of ideas...
- Should decide which thrusts onboard
- Networking : one of them
 - A fundamental segment of internet to understand
 - Clean-slate approach, beyond-current-thinking and designs
- Consolidate knowledge generated worldwide
 - *Do we know what we know already ?*
- Seek / suggest connecting threads with other dimensions / disciplines
 - Consolidate all to Internet Science