Technical Focus Area 2
Smart Applications

Technical Focus area 2
Smart network-Intensive Applications: Scope and Introduction

An increasing number of scientific applications require extensive use of high-performance networks to access critical resources and expertise that are often geographically distributed. The deployment and execution of current network-intensive applications over today's networks require heroic effort; network capabilities are often not exposed to developers, and when exposed, they are not used intelligently. Network resources are constantly changing due to the stochastic nature of networks, applications, and attacks; application developers and network operators have to constantly diagnose and repair network/application failures.

Network-Intensive Applications categories:

- **Science applications**
  - **Data movement (bulk and streaming)**
  - **Remote instrumentation**
  - **Distributed visualization**
- **Operator-initiated applications**
  - **Network maintenance**
  - **Diagnostic applications**
  - **Network management applications**
- **Users network query applications**
  - **Network status query**
  - **Network performance query**
  - **Network search query**

Mark Elgan in 2013 on “smart applications”

- **Learn user context and preferences**: By paying attention to our choices and behaviors, software learns to predict what we'll want.
- **Rely on artificial intelligence to make decisions**. Algorithms enable software to discern between relevant and irrelevant incoming information.
- **Contact users to provide contextually relevant information**: Rather than waiting for us to search for something, they can buzz our phones with answers to questions we haven't asked.
- **Act proactively**. Instead of waiting for us to take action, they take action for us.
- **Automate tasks**. Either users or the software can set up if-then commands like programmers do, and they can do so across different applications and services.
- **Communicate as the user**. Software learns to know who you'll communicate with and what you'll say, then does it for you. To the recipient, it appears as though the message comes from you. When both parties are using software agents to communicate, it's just software talking to software.
- **Facilitate users' actions**. Agents figure out what you'll want to do and get it ready for you. By pressing a single button, you can tell the system to do something that would otherwise be a multi-step process.
- **Act with agency on the user's behalf**. Software does something for you without asking permission or informing you in advance.

Smart network-intensive applications in science

What's special about network-intensive applications?

- Really big flows
- What else?

What's special about science?

- Highly distributed and open infrastructure
- Diverse and rapidly evolving applications and participation
- Complex and often unusual devices
- High ambition-to-budget ratio

Other important factors

- Rapidly growing data volumes
- Exascale computers
- Increasing importance of cloud
- Increasing importance of mobile
- Experiment automation
- Ever-more-challenging security environment

Analogies from vehicular transport: Google/Waze

Delivers higher-level services

- Optimize for time or tolls
- Choose car or train or bus
- Route around accidents
- Predict travel time for future trips

Supported by:

- Sensors in roads
- Location, speed, destination information from other users
- User-inputted warnings

Analogies from vehicular transport: Autonomous vehicle management

- Optimize for various metrics:
  - Optimize aggregate throughput
  - Avoid accidents
  - Reduce pollution
- Respond to events: e.g., congestion, accidents
- Provide planning functions: e.g., evacuation
- Secure

Supported by “smart roads”:

- Sensors that deliver information required for effective autonomous management
- Inter-vehicle signalling
- Smart road-to-vehicle signalling
- Support controls of e.g. traffic lights
- Allow for incremental deployment and graceful degradation in capability

Some examples of smart network-intensive applications in science

Flow-oriented applications:

- Transfer this data from X to Y by time T
- Ensure this flow has QoS Q
- Tell me when this flow will complete

Distributed science intent:

- Enable scientists A, B, and C to collaborate “securely, efficiently, and reliably” on data D [placement, network, perimeter configuration, ...]
- Automated experiment system can meet goal of 1000 experiments per day across five institutions

For system operators:

- Diagnose and correct performance and security problems
- Explain current state of system and possible risk factors

Other:

- Scientist S can engage effectively and securely with experiment as she transits work->car->home->hotel

High fidelity nf & ff HEDM, µ-CT

Processing Compression

Online µ-CT

Preprocessing

Online ff-HEDM

Preprocessing

source beamline

Initialization

Prior info on material's mechanical behavior

Material properties experimental data

µ-CT & HEDM data

Reconstruction

Initial FE mesh

Calibration

Param set

Dynamic loading

Initial structure

µ-CT data

Registration Reconstruction

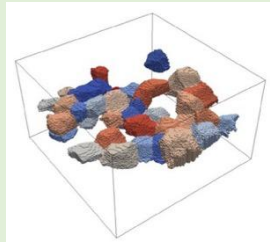
Object

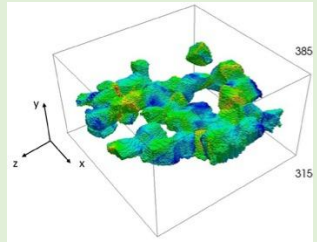
Update

FE mesh

Param set

Diff. data





Ensemble simulation

Predicted state

Analysis

Region of interest for zooming

Validation

New experiments

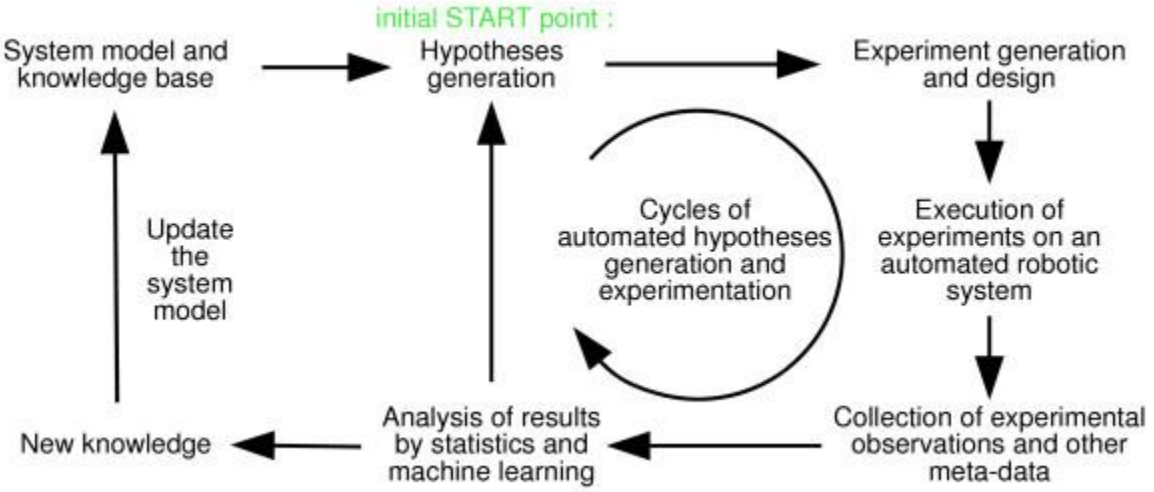
New scientific understanding

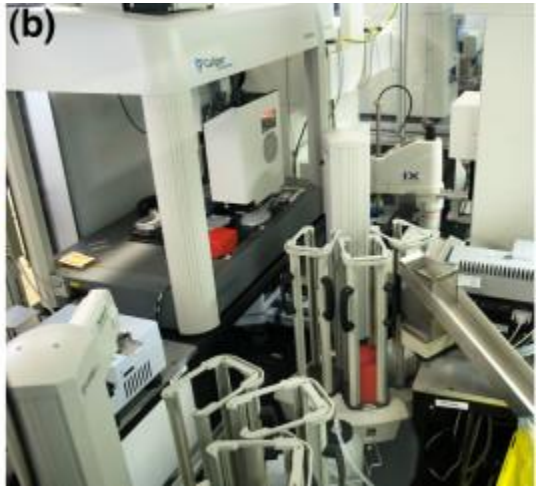
Sensitivity analysis

Validation of simulation

Full reconstruction of experiment

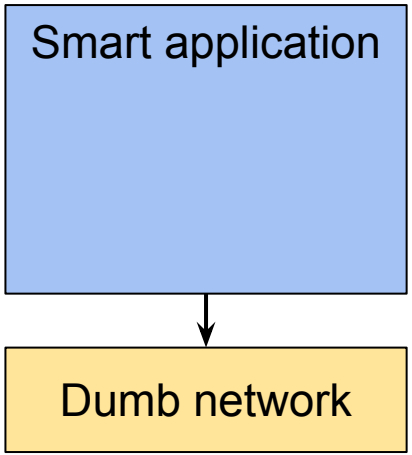
Smart applications: Automated distributed experiments



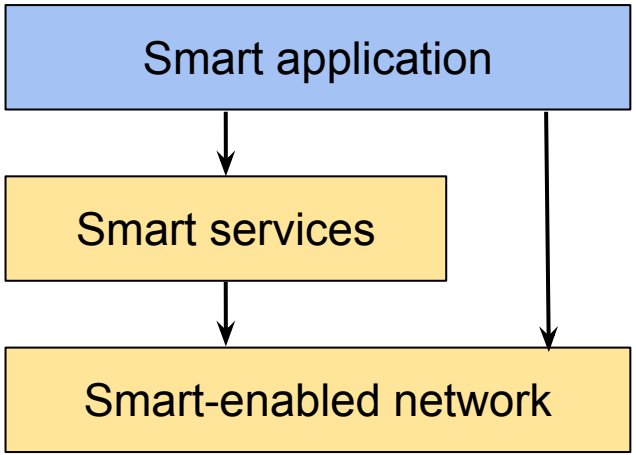


Smart network-intensive application architecture

Hard:



What we want:



We want **smart services** and a **smart-enabled network** to simplify application development.
What are smart services? What is a smart-enabled network?

Technical Focus Area 2
Smart network-intensive applications: Breakout questions

1. Can we create a taxonomy of smart network-intensive applications?
2. What are compelling examples of smart network-intensive applications that, if available within 10 years, would have transformative impact?
3. What are the major obstacles to realizing the various classes of smart applications?
4. What smart network capabilities do you believe can simplify the development of smart applications? Can we identify desirable smart services?

Reading materials provided by attendees