A Vision for Southern Innovation:
"IT-based Complex Problem Solving"

Edward Seidel

Director, Center for Computation
& Technology

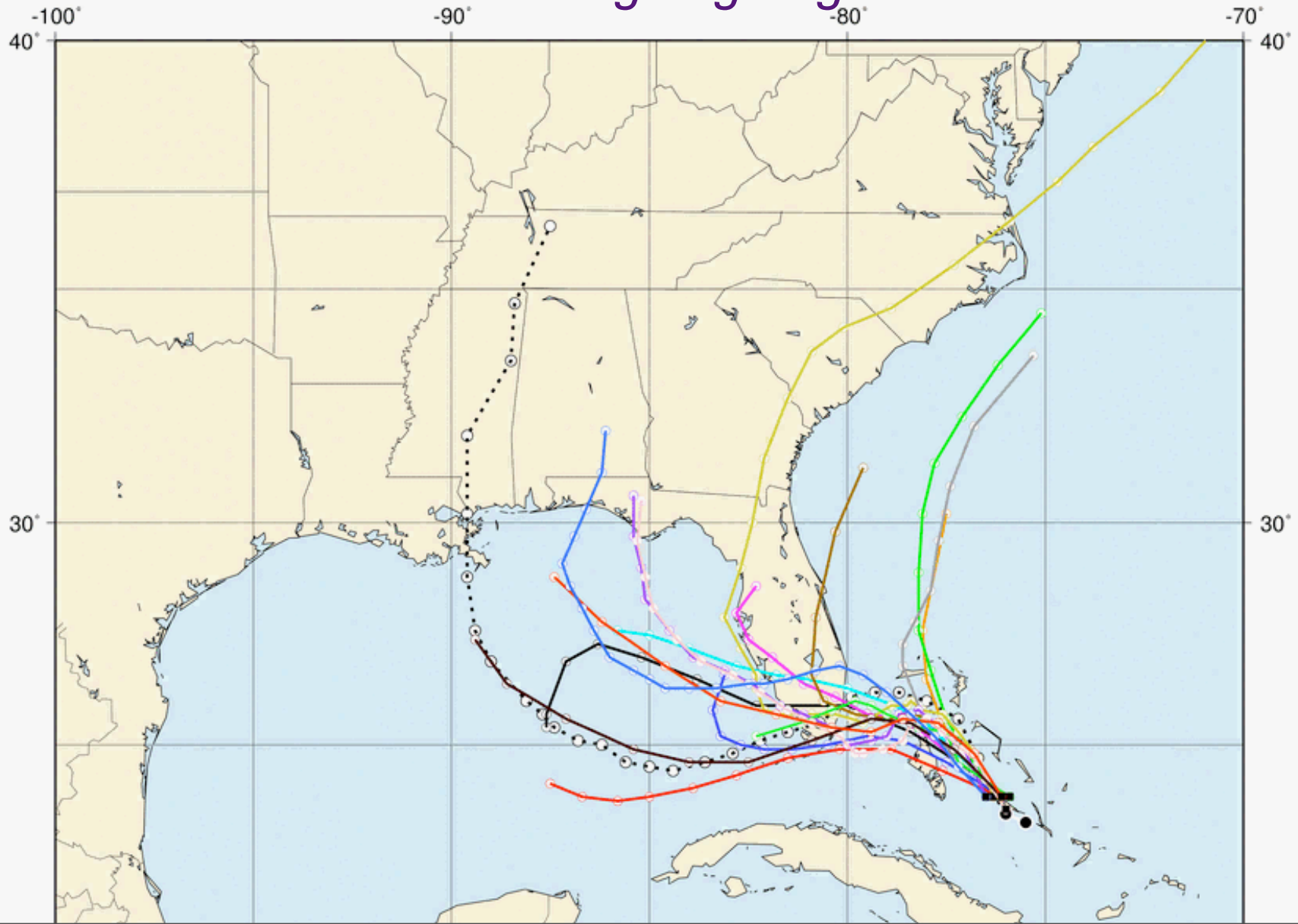Louisiana State University

Complex Problems

12.000
SOLVING COMPLEX PROBLEMS
MIT

Mission 2009

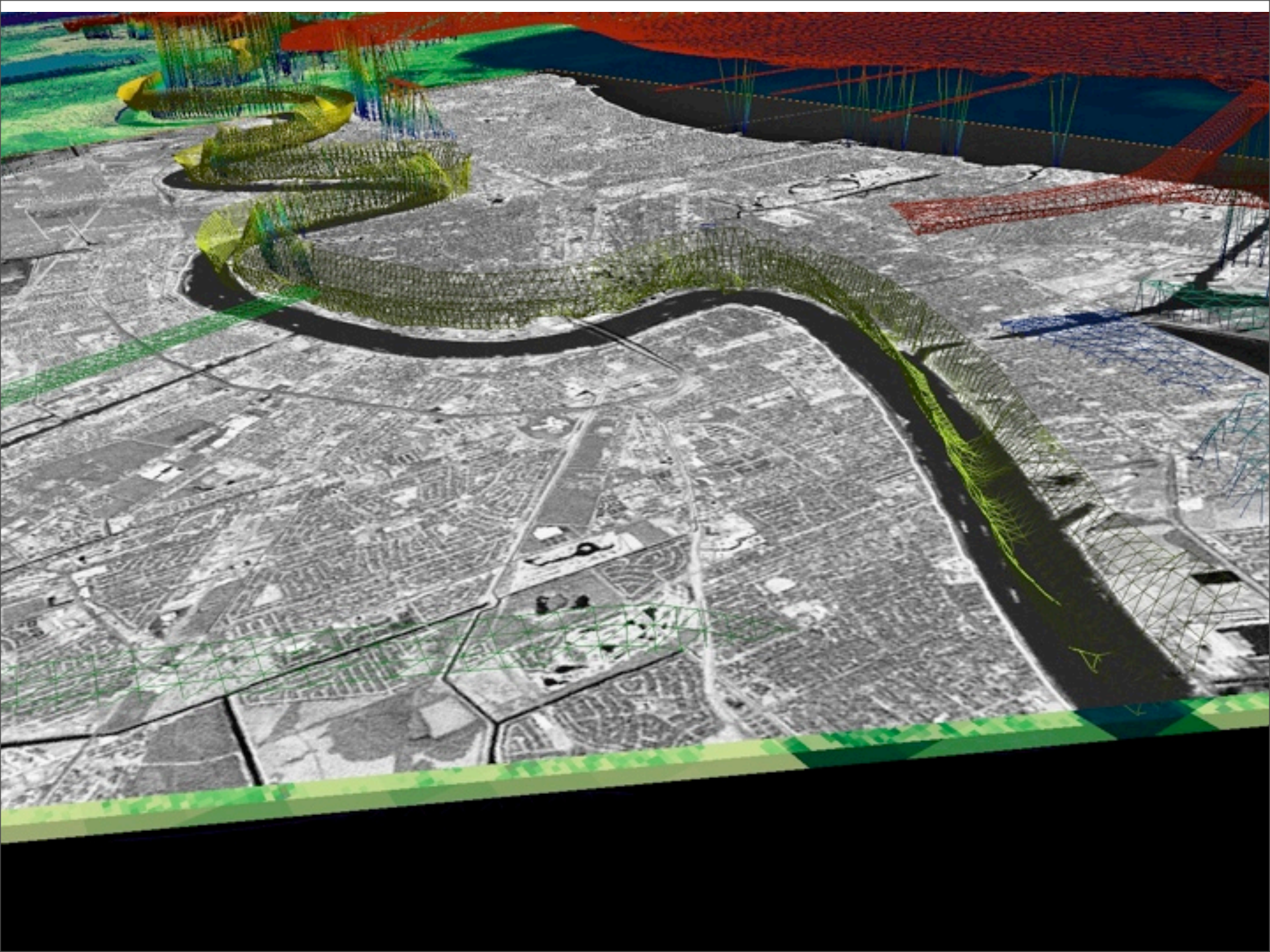"The Great Wave at Kanagawa" by Katsushika Hokusai (public domain)

An Important Complex Problem

Where is it going to go?

More Complexity
Land Loss at Isle Dernieres

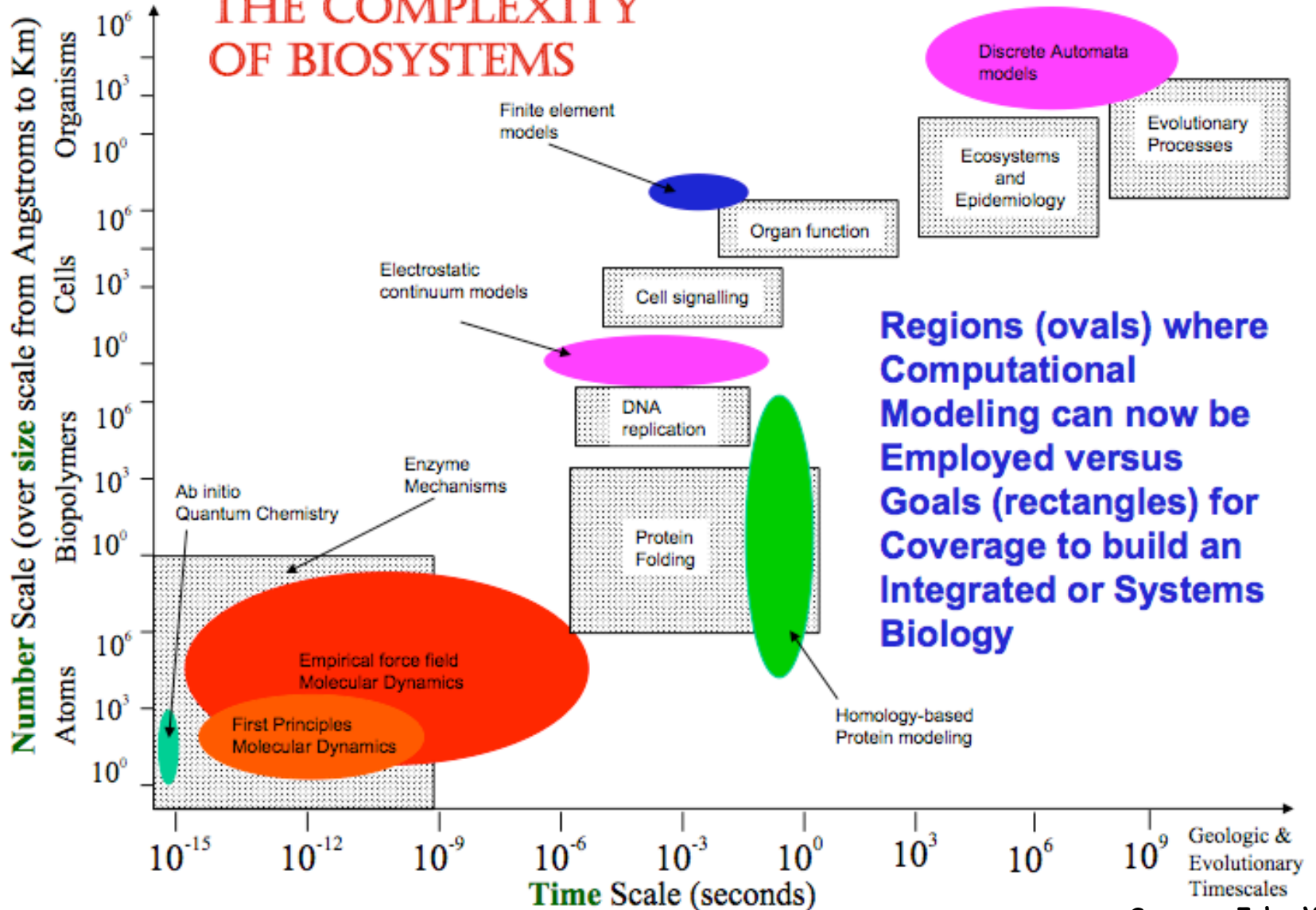# More Complexity
Land Loss at Isle Dernieres

THE COMPLEXITY OF BIOSYSTEMS

Source: John Wooley

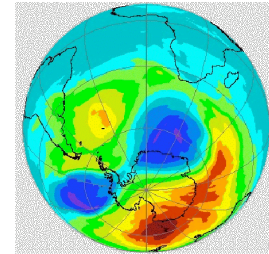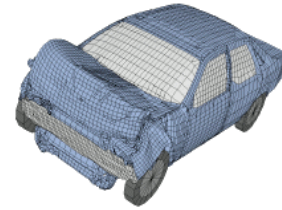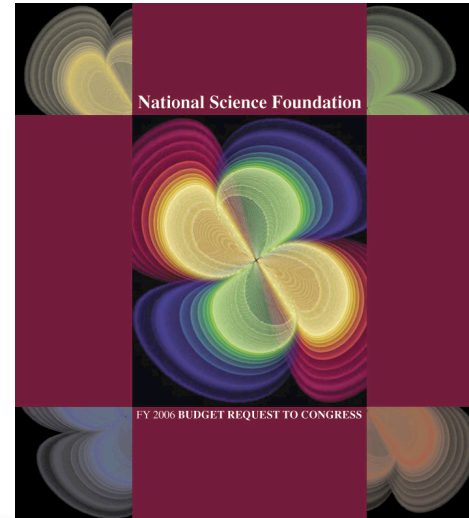# Challenges to Complex Problems
"Third Pillar" of Comp. Science (not computers)

- Applications
- Communities
  - No single group, university, or state can do these problems
  - Must integrate CS, Math, Bio, Sensors, Engineering, more...
- Data everywhere
  - Supercomputers generate petabytes

Data Tsunami

"Cyberinfrastructure"

Changing How Research is Done

Southern Investments

Optical Networks and HPC

- LA's Vision 20/20: $25M annually across 5 campuses
- Louisiana Optical Network Initiative (LONI)
  - $50M: Gov. Blanco leadership ripples across region
  - Creating most advanced network in the US
  - New 100 TeraFlop commitment: biggest facility in nation, equal to all current NSF facilities combined!
    - Possible due to clusters: Thomas Sterling
- Oak Ridge National Lab
- National Lambda Rail
  - $100M USA Optical Backbone. Locally funded!! No Federal $$
  - Other countries: $100'sM, Canada, Poland, Holland, Czech...
- SURA investments catalyzing region
  - $1M towards support of regional HPC, network use
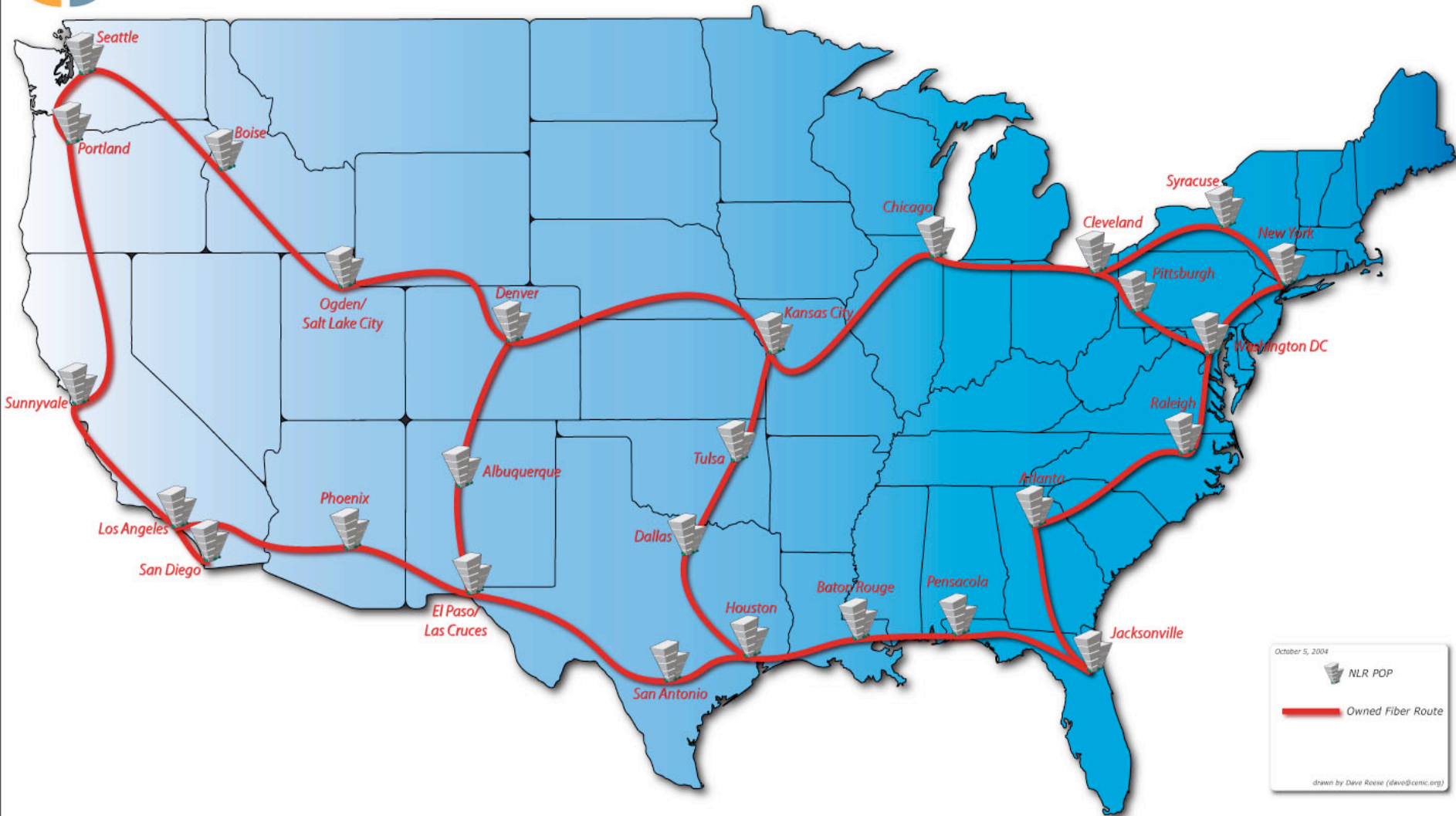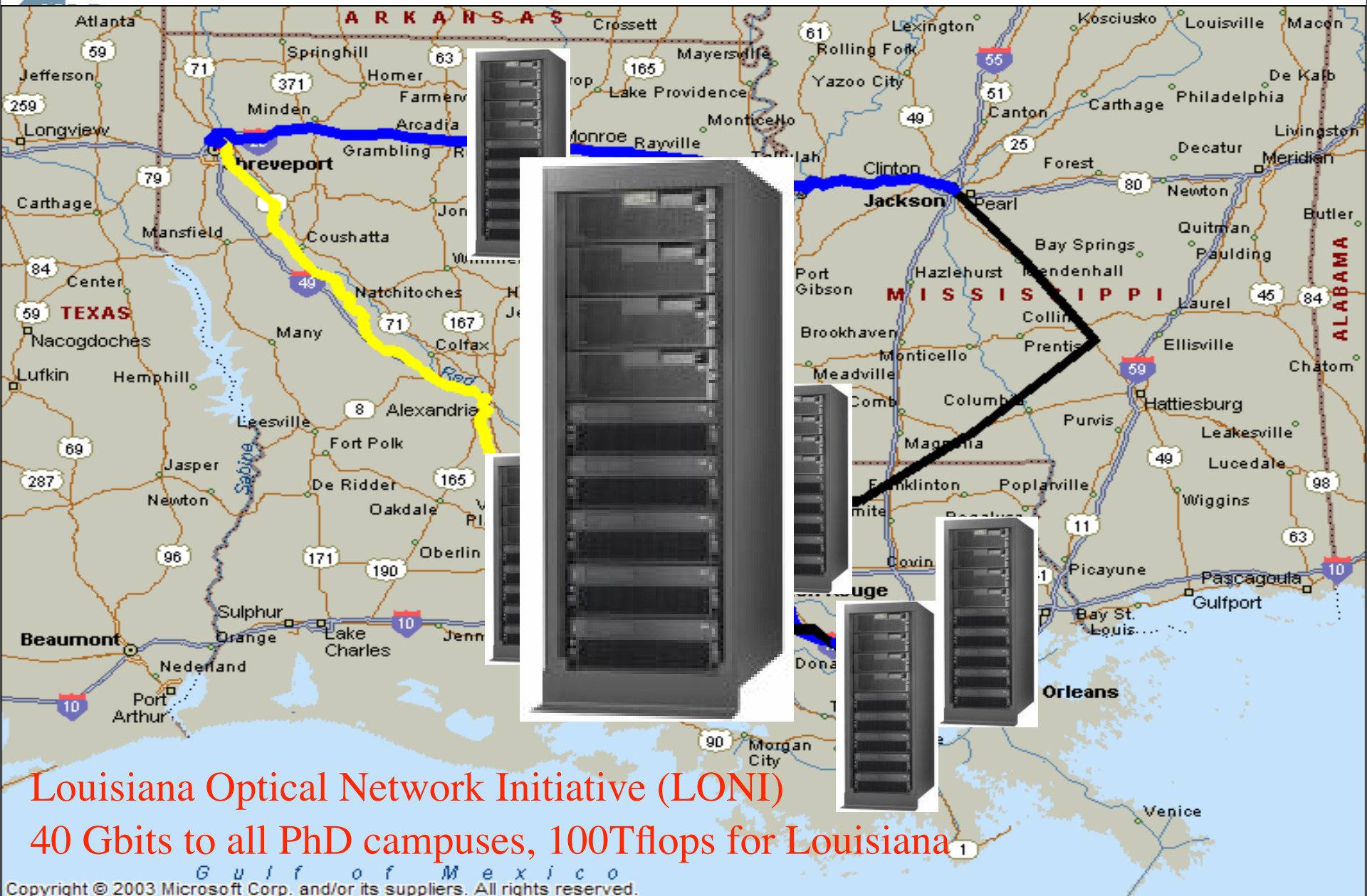
Louisiana Optical Network Initiative (LONI)
40 Gbits to all PhD campuses, 100Tflops for Louisiana
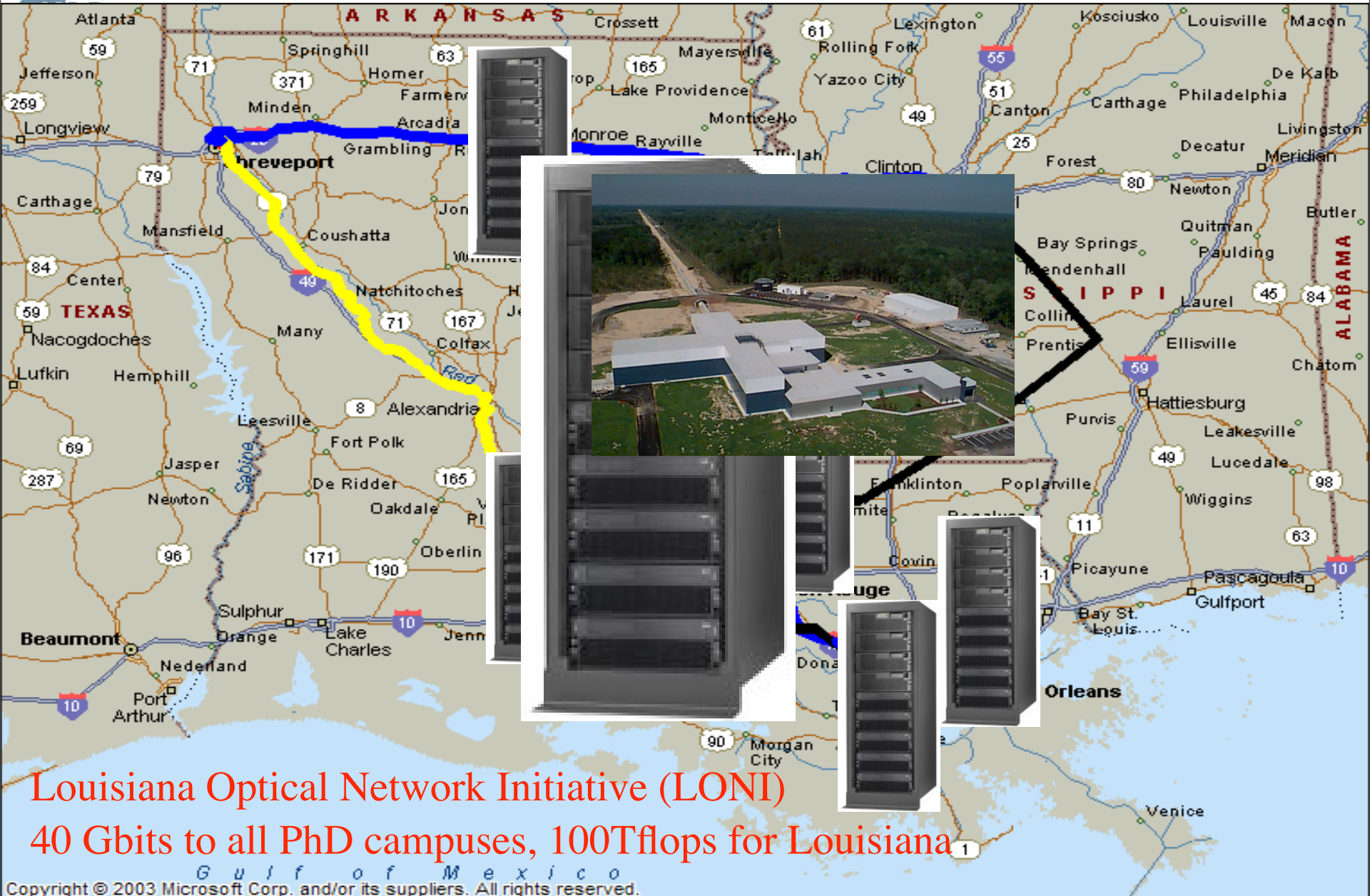
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Leveraging Optical Nets for Complex Problems

- LONI leading US infrastructure
  - Competitive for future development:
    - $17M NIH grant, $70M Century, Delta proposal
  - Connecting sites, catalyzing collab.
- SURA region: 50% NLR nodes, uses only 14% NSF HPC capability! (3.5:1 per capita)
  - States can partner with SURA to address this!
- Many applications not possible today
  - Education, Bio & Health Sciences, Coastal Research, ...
  - Dramatic effect on collaborations, funding across state
    - Example: HD video for education: requires 1.5 Gbit
- Southern states investing to be competitive for industry
  - Example: Hollywood ultra HD distribution: 13 Gbit
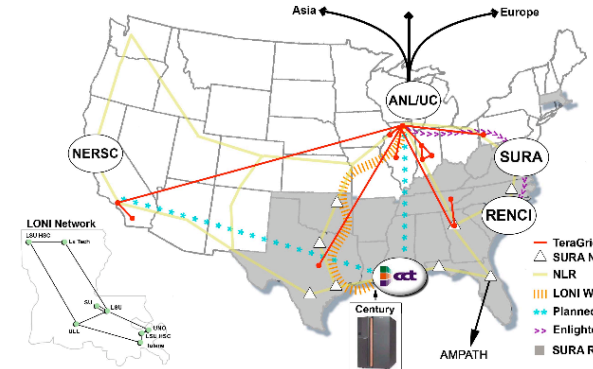
Recommendations

Good advice for all from PITAC, others

Presidential IT Advisory Committee (PITAC)

Computational Science: Ensuring America's Competitiveness

"Among the obstacles to progress are rigid disciplinary silos in academia ... These silos stifle the development of multidisciplinary research and educational approaches essential to computational science. Our report recommends that both universities and Federal R&D agencies must fundamentally change these organizational structures to promote and reward collaborative research."

Recommendations from PITAC

- Universities must significantly change organizational structures: require multidisciplinary & collaborative research to remain competitive in global science.

- Federal investments must rebalance to:
  - *Software*: create reliable, easy to use, scalable software that will enable scientists to focus on discovery
  - *Hardware*: develop, prototype, evaluate new hardware architectures to deliver larger peak and sustained performance at the petaflop level for scientific apps
  - *Data*: focus on data-intensive solutions to address the coming data explosion with advances in sensors and sensor networks

Source: President's Information Technology Advisory Committee

www.nitrd.gov/pitac

The CCT Interdisciplinary Model

Assistant Director for Computing Applications

Core CS: Gabrielle Allen

- Computational Frameworks
- Grid Computing
- Computational Mathematics
- Scientific Computing
- Networks, Sensors & GIS

Coast to Cosmos (C2C): Jorge Pullin

- Numerical Relativity
- CFD
- Coast/Climate Modeling
- GeoSciences & Engineering
- Astro

Visualization, Interaction and Digital Arts (VIDA): Steve Beck

- Scientific Visualization
- Human Computer Interaction
- Digital Audio & Music
- Digital Media
- Collaborative Environments

Material World

- Computational Chemistry
- Computational Biology
- Medical Computing
- Computational Material Science

Business

- Financial Modeling?
- Virtual Organizations?
- Scheduling?
- Service Agreements?
- Decision Sciences?

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- Financial Modeling?
- Virtual Organizations?
- Scheduling?

> Forecast entire coast using LONI, NLR. Must collaborate across states

The CCT Interdisciplinary Model

Assistant Director for Computing Applications

Problem: we still do not train, reward people in collaborative work!

- Academia still rewards individual PI, single author papers, discourages multi-author
- Educational process must begin to address, all the way to kindergarten

Networks, Sensors, GIS

Astro

Material W...

Computational Chemistry

Computational Biology

Business

Financial Modeling?

Virtual Organizations?

Scheduling?

Forecast entire coast using LONI, NLR. Must collaborate across states

Complex Problem Solving for the Innovation Economy

Innovation Economy

- The Innovation Economy requires vibrant communities

  When we make a decision about where to locate a Hewlett-Packard facility, we have one criterion in mind. We go where the highly skilled and creative people are." Carly Fiorina

- Creating environment of global leadership & innovation to attract best in world

  *"To attract high tech firms… finance, tax-structure, capital costs, business climate... but the most substantial is **history**, with a high tech presence produced by government research facilities and/or a highly skilled labor pool left from a **previous** high-tech success."*

  "Research Centers are the most important factor in incubating high-tech industries. Cost factors wane in the later stages of development. Low cost is not a sustainable advantage."

  MILKEN INSTITUTE
  A PUBLICLY SUPPORTED INDEPENDENT ECONOMIC THINK TANK

- Partnerships with industry for complex problem solving: NCSA example

Council on Competitiveness
High Performance Computing (HPC) Survey

- Nearly 100% said HPC essential for business survival. Why?
  - "Unique ability to solve complex problems...for competitive advantage." "Drives innovation, R&D effectiveness, productivity"

- Companies fail to use HPC aggressively enough: Can't solve problems! Why?
  - "Single most important factor: lack of computational scientists"
  - "HPC viewed as cost rather than investment"
  - "Hardware/software tools missing"

- Dramatically more powerful supercomputers would
  - Deliver strategic, competitive benefits (e.g., fluids in porous media), save billions to bottom line

Leveraging LA Investments

- LONI (Statewide), CCT (LSU), LITE (UL), CCS (Tulane), IfM (LA Tech), others
  - Building advanced infrastructure; Attracting top talent
- NIH INBRE
  - $16M biomedical research network
- NSF RII EPSCOR Proposal (under review)
  - $12M, involves all LA research campuses, connected by LONI; Proposed "CyberTools", outreach, training
- NSF HPC OPS Proposal
  - $6M for staff to make LONI part of US TeraGrid
- NSF National Center Proposal
  - $75M, Century (Feb, 2006), Delta (Nov 2006), ...
  - Would bring nation's most powerful computer to LA

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The 1-2 Punch

- Universities must invest to further leverage these investments
  - Much more competitive for recruiting top faculty, students, staff in computational sciences
  - Need a statewide plan to exploit this to bring them here!
- Corporate partnerships critical to these efforts, and to LA
  - Developing tech hubs, attracting top companies to invest in partnership with universities
  - U of Illinois: $120M+ over 20 years: Schlumberger, Boeing, JP Morgan, Motorola, Caterpillar, etc...
  - Mosaic: web browser added $1 trillion to world economy

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Summary

- ## Complex problem solving is here, critical to future
  - Interdisciplinary work requires new ways of education, work, social ethic, reward system, organizational structures, business
  - *Need to reorganize education system, universities, government*
  - *Need education in complex problem solving from K-Faculty*
- ## South is making investments in IT infrastructure
  - Richest optical network infrastructure; HPC investments beginning, but usage very low
  - *Must accompany with recruitment of people*
  - *Must collaborate, not compete across region*
- ## So are others:
  - "EU leaders commit to the ambitious goal of making Europe the most competitive and dynamic knowledge-based economy in the world by 2010"
- ## Industry, needs and demands IT-based complex problem solving future
  - *Need to find ways to partner with them*

Lessons Not Learned

- *Thomas Jefferson circa 1780:* knowledge-products show *infinite expansibility.* They do not get used up, physically

- *Panel on Large Scale Computing in Science and Engineering,* interagency, 1982

- *From Desktop to Teraflop: Exploiting the U.S. Lead in High Performance Computing,* NSF, 1993

- *Information Technology Research: Investing in Our Future*, PITAC 1999

- *The Biomedical Information Science and Technology Initiative*, NIH, 1999

- *Making IT Better,* National Academies, 2000

- *Embedded Everywhere,* National Academies, 2001

- *High-Performance Computing for the National Security Community*, DOD, 2002

- *Knowledge Lost in Information,* NSF, 2003

- *Revolutionizing Science and Engineering Through Cyberinfrastructure*

Source: Dan Reed