GLOBAL SECURITY INITIATIVE

Computing Drivers for Wicked Problems

Smoky Mountains Computational Sciences and Engineering Conference
September 1st, 2015

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2002-2012

MIT Lincoln Laboratory
Technology in Support of National Security

2012-Present

Image sources
http://outreach.asu.edu/chavezprograms/devils-training
https://www.ll.mit.edu/about/History/historybook.html
BACKGROUND: A BIT MORE SERIOUS

pMatlab and LLGrid

Large Graphs

Interdisciplinary Research

- Computational
  - Humanities
  - Social Science
  - Life Sciences
  - Political Sciences
- Decision Environments

2002-2012 ~2008-2012 2012-Present

Figure 7. Layered architecture. The pMatlab library implements distributed constructs, such as vectors, matrices, and multi-dimensional arrays and parallel algorithms that operate on those constructs, such as redistribution, Fast Fourier Transform (FFT), and matrix multiplication.

Figure 3. Anatomy of a Map. A map for a numerical array is an assignment of blocks of data to processing elements. It consists of a grid specification (in this case a 2 x 2 arrangement), a distribution that specifies how each dimension is partitioned, a list of processors that defines which processors actually hold the data (in this case processor list (in this case the array is mapped to processors 0, 1, 2, and 3)).

MATLAB constructors are overloaded to take a map as an argument, and return a dsct, a distributed array.

mapA = map ([2 2], [], 0:3);

Grid specification together with processor list describe where the data is distributed.

Distribution specification describe how the data is distributed (default is block).

A = zeros (4, 6, mapA);

High Bandwidth 3-D Communication Network
- 3D interconnect (3x)
- Randomized routing (2x)
- Parallel paths (8x)
- 146 combined bandwidth while maintaining low power
- Optimized for sparse matrix processing access patterns

Cache-less Memory
- Parallel Cacti Mem.

3-D GRAPH PROCESSOR
- 1024 Nodes
- 75GOPS* 
- 10 MSOPS/Watt
- Efficient load balancing and memory usage
- Reduction in programming complexity via parallelizable array data structure

Accelerator Based Architecture
- Dedicated VLIW computation modules
- Statistic sorting technology
- 25x-100x throughput

Custom Low Power Circuits
- Full custom design for critical power (voltage power efficiency)


Design Aspirations

**Leverage Our Place**
ASU embraces its cultural, socioeconomic and physical setting.

**Transform Society**
ASU catalyzes social change by being connected to social needs.

**Value Entrepreneurship**
ASU uses its knowledge and encourages innovation.

**Conduct Use-Inspired Research**
ASU research has purpose and impact.

**Enable Student Success**
ASU is committed to the success of each unique student.

**Fuse Intellectual Disciplines**
ASU creates knowledge by transcending academic disciplines.

**Be Socially Embedded**
ASU connects with communities through mutually beneficial partnerships.

**Engage Globally**
ASU engages with people and issues locally, nationally and internationally.
WE LIVE IN A TIME OF WICKED PROBLEMS

Climate change poses another significant challenge for the United States and the world at large. As greenhouse gas emissions increase, sea levels are rising, average global temperatures are increasing, and severe weather patterns are accelerating. These changes, coupled with other global dynamics, including growing, urbanizing, more affluent populations, and substantial economic growth in India, China, Brazil, and other nations, will devastate homes, land, and infrastructure. Climate change may exacerbate water scarcity and lead to sharp increases in food costs. The pressures caused by climate change will influence resource competition while placing additional burdens on economies, societies, and governance institutions around the world. These effects are threat multipliers that will aggravate stressors abroad such as poverty, environmental degradation, political instability, and social tensions – conditions that can enable terrorist activity and other forms of violence.

The global energy revolution is bringing electricity to millions, while at the same time climate change exacerbates our greatest vulnerabilities. A global middle class is growing exponentially as education, stability, and prosperity increase. Yet inequality, corruption, autocracy, and environmental degradation threaten to destabilize, dehumanize, and deflate that growth. We have seen great advances in public health and life expectancy, due in part to our signature development initiatives, but gaps remain, particularly in fragile states and in places where poor governance undermines these gains and increases the risk of pandemics and violent conflict.

Significant complexity and interconnectivity, limited resources.
A university-wide interdisciplinary hub for global security research

**VISION:** A security and intelligence landscape transformed through interdisciplinary research and discovery, in which defense, development and diplomacy operate collaboratively to drive positive outcomes for complex global challenges.
The man with the power to predict economic success | ASU News

Shade Shutters shows some of the economic analytics he has produced to assist communities in making development decisions, in the Decision Theater in Tempe on July 28. He is a research scientist in ASU’s Global Security Initiative.

Photo by: Charlie Leight/ASU News
Download image

There’s a mild disappointment when you meet Shade Shutters and listen to him discuss his area of study. Because after you learn he’s a research scientist in ASU’s Global Security Initiative, you really want this man with the comforting demeanor and pleasant eyes to tell you he’s studying the impact of reducing solar gain on communities.

After all, his name is Shade Shutters.

Once you get past the absence of typecasting, all disappointment is washed away because what Shutters will tell you is much more interesting than the amusement of an obvious name game.

Like how this former international finance professional went back to school to get a doctorate in biology so he could better understand his field – more on that in a bit. Or how he has developed an algorithm that can divine which industries fit best in a particular city. He can even help a city determine whether it has the right makeup to become a creative or “green” economic hub.

Yes, in a sense, Shutters has created digital clairvoyance for the world’s civic economies.

This is how it works:

Say Happyland, Oklahoma – an actual town, by the way – believes it’s the perfect location for a pharmaceutical industry, but the city leaders want to consult Shutters just to be certain. He’ll collect the city’s metrics, then overlap the data associated with the pharmaceutical industry into his algorithm. The results will tell him whether Happyland has the appropriate infrastructure and complementary businesses and whatnot to support the decision to woo a pharmaceutical company.

NSF award will expand scope, impact of ASU water research | ASU News

A new National Science Foundation grant will allow ASU to expand the geographic scope of Decision Center for a Desert City’s work beyond Phoenix to include other cities dependent on Colorado River water sources, such as Lake Mead.

Photo by: Wikimedia Commons

The four-year award, the third made to DCDC in its 10-year history, brings the total NSF investment in the center to $18 million. It will allow ASU to expand the geographic scope of DCDC’s work beyond Phoenix to include cities dependent upon Colorado River water in states like Colorado, Nevada and California to explore transformational changes that will be necessary to sustain water supplies well into the future.

Decision Center for a Desert City, which is a research unit of the Julie Ann Wrigley Global Institute of Sustainability at ASU, conducts climate, water and decision research, and it develops innovative tools to bridge the boundary between scientists and decision makers.

DCDC researchers work closely with the Decision Theater Network to engage stakeholders using models and simulations that visualize alternative futures and to promote dialogue about sustainability solutions.

“It is an unprecedented time to conduct this type of use-inspired research for the Colorado River Basin region,” said Dave White, director of Decision Center for a Desert City and Global Security Initiative fellow. “It comes with a greater sense of urgency and a greater sense of understanding of the scale and scope of the changes that are likely necessary to transition the cities and the region into a more sustainable state over the next several decades.”

New GSI Center for Cyber Security and Digital Forensics

Director: Prof Ahn
(with faculty from Business, Law, Psychology; in addition to Computer Science)

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https://asunews.asu.edu/20150824-nsf-award-decision-center-desert-city
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THE 10 PROPERTIES OF WICKED PROBLEMS*

as defined in


and revisited in

THE 10 PROPERTIES OF WICKED PROBLEMS*

1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not true or false, but good or bad.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a “one-shot” operation; because there is no opportunity to learn by trial and error, every attempt counts significantly.
6. Wicked problems do not have an exhaustively describable set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways.
10. The planner has no right to be wrong.

As defined, no way to make progress.

So why try?

“The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature of these problems.” Rittel, Webber 1973
WICKED PROBLEMS: Another Look

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Ultimately, need for better decision and planning tools and processes
For decision tools to be effective by linking scientific knowledge to decision making, you need:

- **Saliency:** Relevance of the model to decision makers’ needs
- **Credibility:** Validity, reliability and technical accuracy of the knowledge and analysis presented in the model
- **Legitimacy:** Perceptions that the knowledge and information is respectful of stakeholders diverse values and beliefs


The Foresight Initiative

Saliency
- Visual Analytics
  - Data Reduction
  - Data Fusion
  - Geo-narratives

Credibility
- Modeling & Simulations
  - Dynamic Recursive
  - System Dynamics
  - Discrete
  - Agent-based
  - Multi-Resolution

Legitimacy
- Stake Holder Engagement
  - Anticipatory Analytics
  - Framing Narratives
  - Policy/Plans/Scenario Assessment
  - Collaborative Decision Making
RECENT PUBLICATIONS AND PRESENTATIONS

- Ed Finn. *Collaborative and Immersive Geo-narratives.* Balance-Unbalance Conference
- Ross Maciejewski, Paul Westerhoff, Dave White. *An Interactive Web-Based Geovisual Analytics Tool to Explore Water Scarcity in Niger River Basin.* EuroVis Conference
- Steve Corman, Jun-Yi Tsai, Hasan Davulvu, Ross Maciejewski. *Studying Climate Change, Framing, and Social Unrest in West Africa using Computational Methods.* Workshop on Computational Approaches to Advance Communication Research International Communication Association Conference
At their core, wicked problems are the study of interactions.

A deeper fundamental understanding of graphs has the potential to elucidate the “tipping links.”
SUMMARY & DISCUSSION

• Emerging global challenges drive the need for efficient **computational environments** for wicked problems

• Environments: not just hardware
  – Requires efficient computation for both traditional physics-based/signal processing (dense) and graph/database algorithmic kernels
  – Requires tight coupling (and co-design) of display technology with computational hardware and software
  – Requires tuning computational power to the stakeholder requirements (**more is not always better**)

• Graph/database processing is still a challenge

• **Scaling domain expertise** has potential to transform computational environments for wicked problems
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