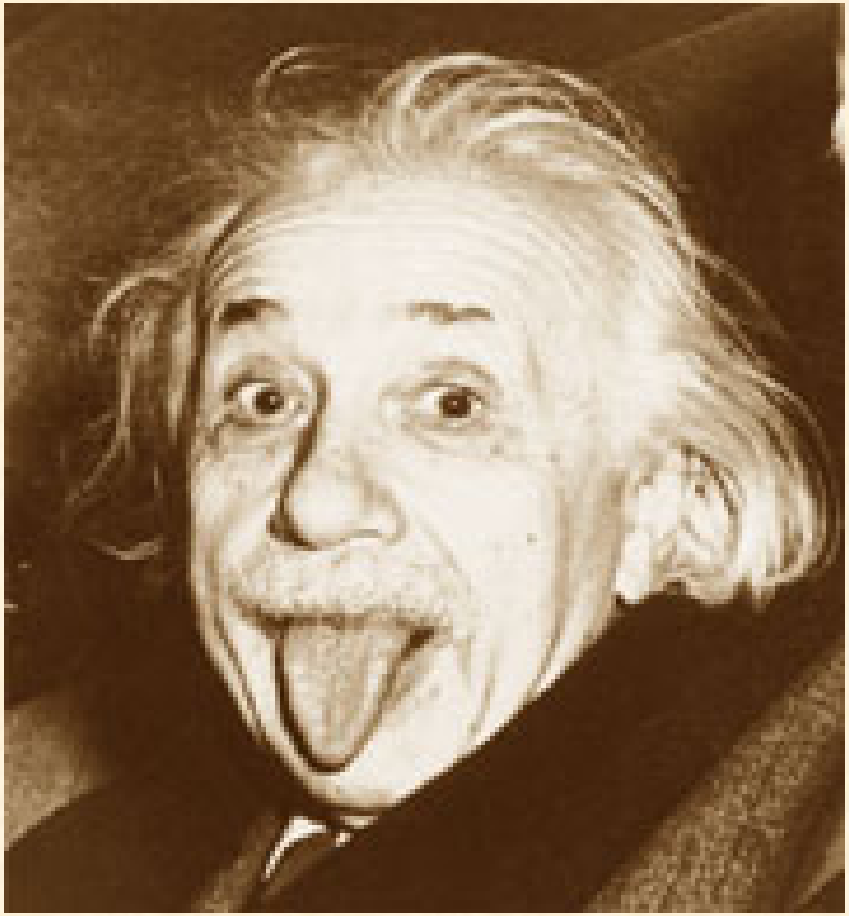
Software Agents

Strength thru Collaboration



Explanations should be "as simple as possible, but no simplier."

Mark T. Elmore
Software Agent Research
Oak Ridge National Laboratory

ornl
Oak Ridge National Laboratory

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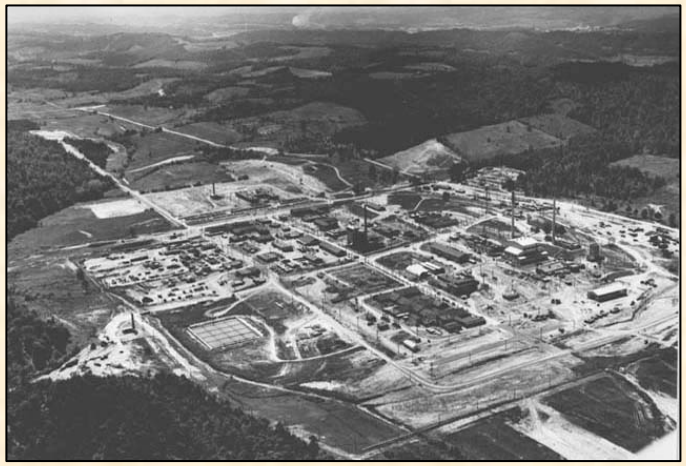
ORNL Software Agent Research Solutions
✓High-Volume ✓High-Speed ✓Real-Time

Oak Ridge National Laboratory



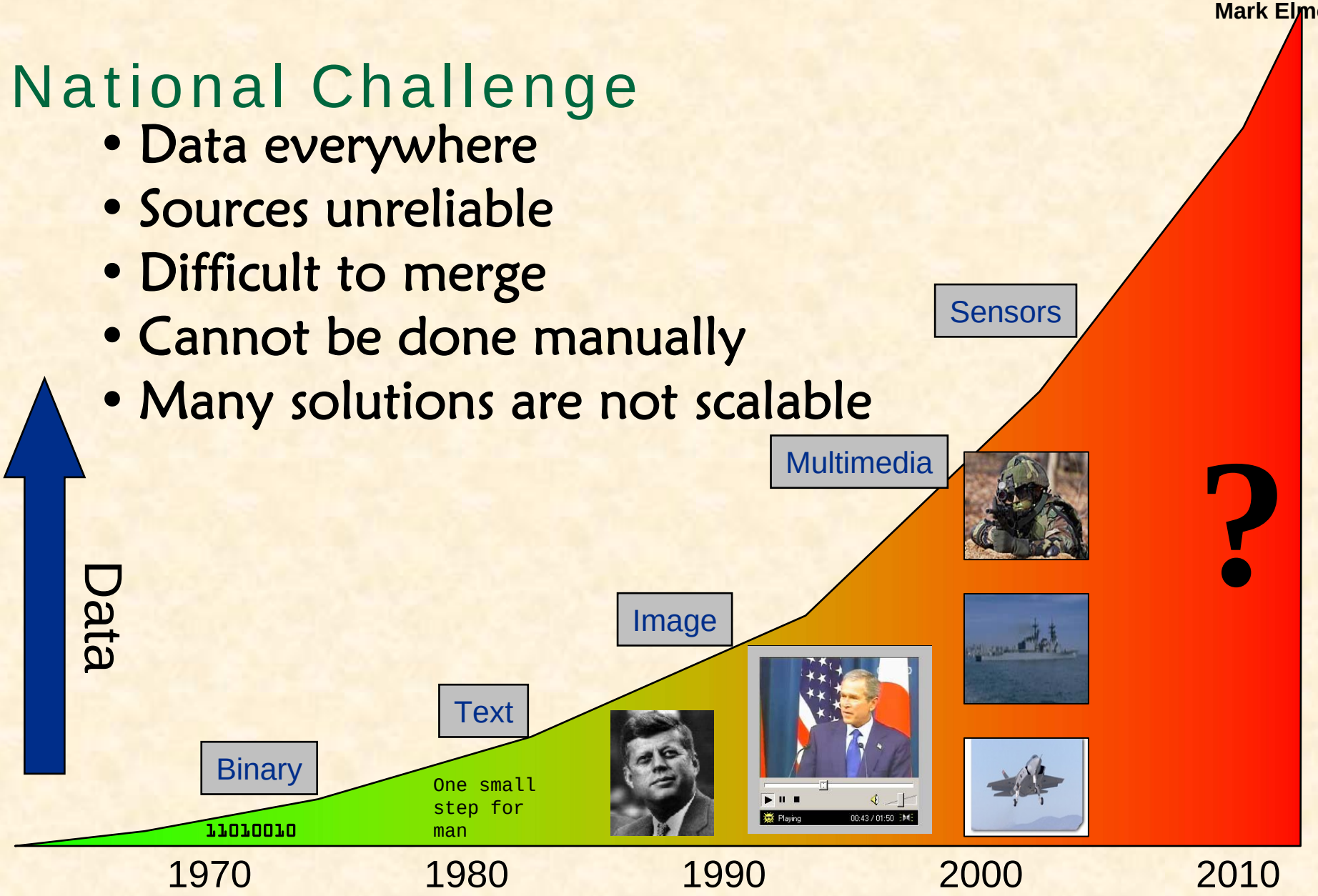
- **Established in 1943 for the World War II Manhattan Project.**
- **ORNL today pioneers the development of new energy sources, technologies, and materials**
- **The advancement of knowledge in**
  - **Biological, Chemical,**
  - **Computational, Engineering,**
  - **Environmental, Physical, and Social Sciences.**
- **Budget: $1B+, 80% Department of Energy, 20% work for others.**
- **3800 employees, 1500 scientists and engineers**
- **+ "Visiting Scientists"**

Mark Elmore

- **Computer Science Researcher**
  - **Studying the application of the Software Agent approach to software engineering**
- **Second presentation at InterLab**
  - **InterLab '99 at SLAC**
  - **"Collaborative Management Environment" (CME)**
    - **A prototype proof-of-principle**
    - **Forerunner of DOE's ePME system**
      - **electronic Portfolio Management System**
      - **Currently under roll-out**
  - **Talk was about a new fangled idea from the research realm**
    - **SGML leading to XML**

National Challenge

- Data everywhere
- Sources unreliable
- Difficult to merge
- Cannot be done manually
- Many solutions are not scalable



Examples of the problem

- **Intelligence organizations need analysis over terabytes of archival data**
- **US Army wants to run the battle in real-time from a collection of networked vehicles**
- **The Missile Defense Agency has 3 to 5 minutes to determine what actions to take against a missile launched from anywhere in the world**
- **DHS is responsible for analyzing 10,000 to 300,000 new documents per day**

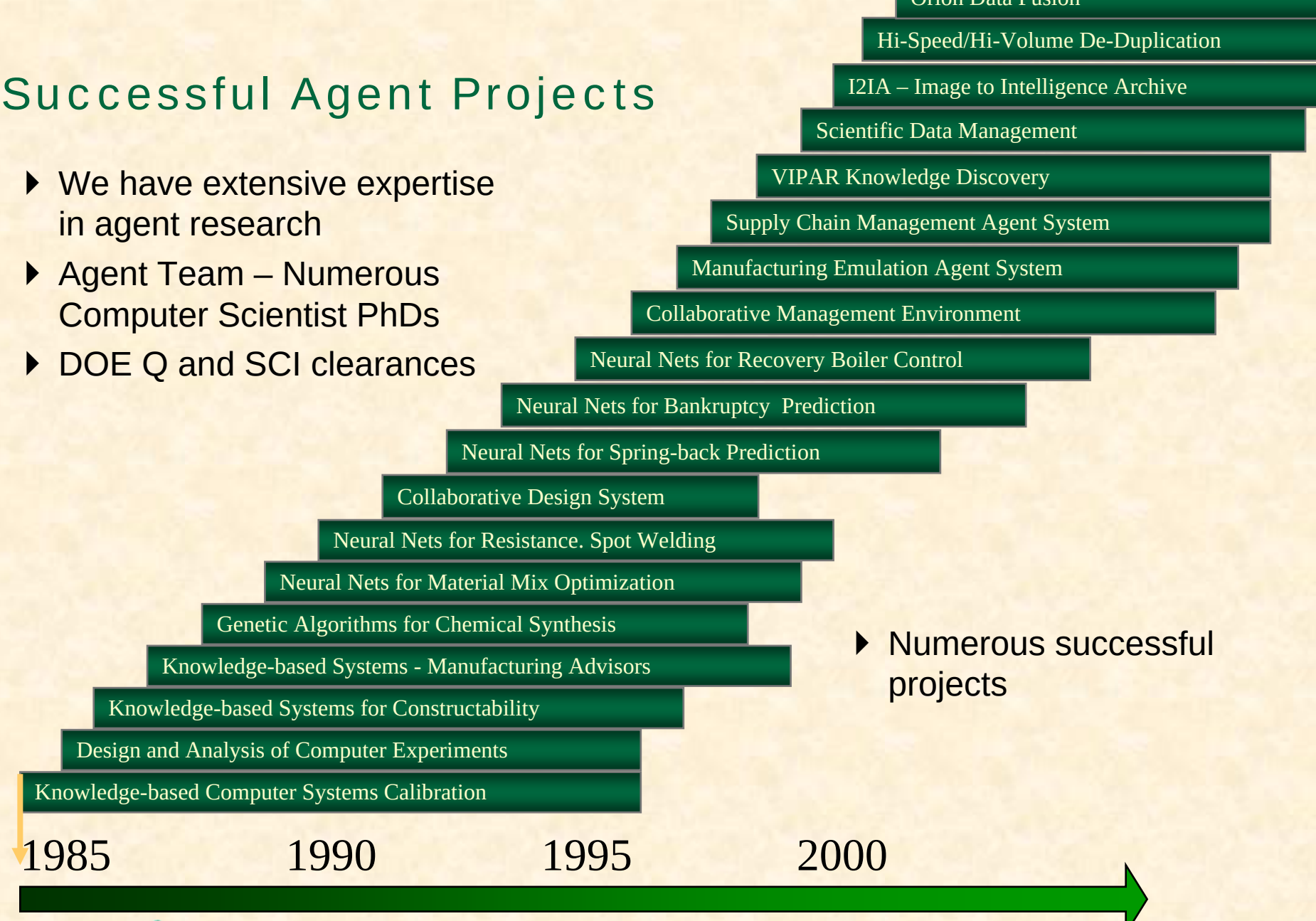
Why ORNL Agents?

✓ ***High-Volume / High-Speed / Real-Time Solutions***

- **Scalable Parallel Processing Solutions**
- **Fault-tolerant and Recoverable Solutions**
- **For problems with *very large*, *distributed* and *diverse* datasets**
  - **Agent-based data fusion**
  - **Agent-based analysis**
  - **Across multiple data sources**
- **Top-notch ORNL scientists *collaborate* with top-notch scientists at other DOE laboratories**
  - ***Deliver effective* agent-based solutions**

Successful Agent Projects

- We have extensive expertise in agent research
- Agent Team – Numerous Computer Scientist PhDs
- DOE Q and SCI clearances



- Numerous successful projects

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Sponsors Who Made our Progress Possible

- U.S. Department of Energy
- U.S. Army (RDECOM)
- U.S. Navy Pacific Command (PACOM)
- Joint Intelligence Command, Pacific (JICPAC)
- U.S. Navy Sixth Fleet Command (C6F)
- U.S. Missile Defense Agency
- Lockheed Martin Tactical Air Systems
- International Atomic Energy Agency
- U. S. Department of Homeland Security
- Tennessee Department of Homeland Security
- Battelle Memorial Institute
- U.S. Intelligence Community

Intelligence Community

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Patents based on ORNL Agent Science

- **“Method for Distributed Document Organization”**
- **“Method for Gathering and Summarizing Internet Information”**
- **“Method for distributed agent-based non-expert simulation of manufacturing process behavior”**
- **“Methods for automatically evaluating a transition from a batch manufacturing techniques to a lean manufacturing technique”**

Refereed Papers (Recent)

- **Real-Time Document Cluster Analysis for Dynamic Data Sets**
  Mark T. Elmore, Joel W. Reed, Thomas E. Potok, and Robert M. Patton, IPSI-Amalfi Conference, Amalfi, Italy. February 2005
  • • • Keynote Address • • •
- **Advanced Decision Support System (ADSS) for Spiral Technology Investments**
  L.D. Chapman, Mark T. Elmore, et al., 24th U.S. Army Science Conference, Orlando, Florida. December 2004
- **A Multi-Agent System for Distributed Cluster Analysis,**
  Joel W. Reed, Thomas E. Potok, and Robert M. Patton, 3rd International Workshop on Software Engineering for Large-Scale Multi-Agent Systems, 5/2004
- **Agent Approach to Service Discovery and Utilization,**
  Paul Palathingal, Sandeep Chandra, Proceedings of the 37th Annual Hawaii International Conference on System Sciences, 1/2004
- **Adaptive Sampling of Text Documents,**
  Robert M. Patton and Thomas E. Potok, 13th International Conference on Intelligent and Adaptive Systems and Software Engineering, Submitted 3/2004
- **VIPAR: Advanced Information Agents discovering knowledge in an open and changing environment**
  Thomas E. Potok, Mark Elmore, Joel Reed and Frederick T. Sheldon, Proc. 7th *World Multiconference on Systemics, Cybernetics and Informatics* Special Session on Agent-Based Computing, Orlando FL, July 27-30, 2003.
  • • • Awarded Best Paper • • •
- **An Ontology-Based Software Agent System Case Study**
  Frederick T. Sheldon Mark T. Elmore and Thomas E. Potok, IEEE Proc. *International Conf. on Information Technology: Coding and Computing*, Las Vegas Nevada, pp. 500-506, April 28-30 2003
- **Dynamic Data Fusion Using An Ontology-Based Software Agent System**
  Mark T. Elmore Thomas E. Potok and Frederick T. Sheldon, *Proceedings of the 7th World Multiconference on Systemics, Cybernetics and Informatics*, 2003
- **A Multi-Agent System for Analyzing Massive Scientific Data**
  Joel W. Reed and Thomas E. Potok, *Proceedings of the International Conference on Software Engineering,* 2003.
- **VIPAR: Advanced Information Agents discovering knowledge in an open and changing environment**
  Thomas E. Potok, Mark Elmore, Joel Reed, and Frederick T. Sheldon, *Proceedings of the IIIS Agent Based Computing*, Orlando, July 27-30, 2003.
- **Multi-Agent System Case Studies in Command and Control, Information Fusion and Data Management,**
  Frederick T. Sheldon, Thomas E. Potok and Krishna M. Kavi, *Submitted* Aug. 18 *Informatica Journal* (ISSN 0350-5596) published by Slovene Society Informatika
- **Suitability of Agent Technology for Command and Control in Fault-tolerant, Safety-critical Responsive Decision Networks,**
  Thomas E. Potok, Laurence Phillips, Robert Pollock, Andy Loebl and Frederick T. Sheldon, *Proc.16th Int'l Conf. Parallel and Distributed Computing Systems*, Reno NV, Aug. 13-15, 2003
- **Critical Energy Infrastructure Survivability, Inherent Limitations, Obstacles and Mitigation Strategies**
  Frederick T. Sheldon, Tom Potok, Axel Krings and Paul Oman, *To Appear Int'l Journal of Power and Energy Systems –Special Theme Blackout*, ACTA Press, Calgary Canada, 2004
- **Managing Secure Survivable Critical Infrastructures To Avoid Vulnerabilities**
  Frederick T. Sheldon, Tom Potok, Andy Loebl, Axel Krings and Paul Oman, *To Appear Eighth IEEE Int'l Symp. on HIGH ASSURANCE SYSTEMS ENGINEERING*, 25-26 March 2004, Tampa Florida.
- **Energy Infrastructure Survivability, Inherent Limitations, Obstacles and Mitigation Strategies**
  Frederick T. Sheldon, Tom Potok, Andy Loebl, Axel Krings and Paul Oman, *IASTED Int'l Power Conference -Special Theme Blackout*, New York NY, pp. 49-53, Dec. 10-12, 2003

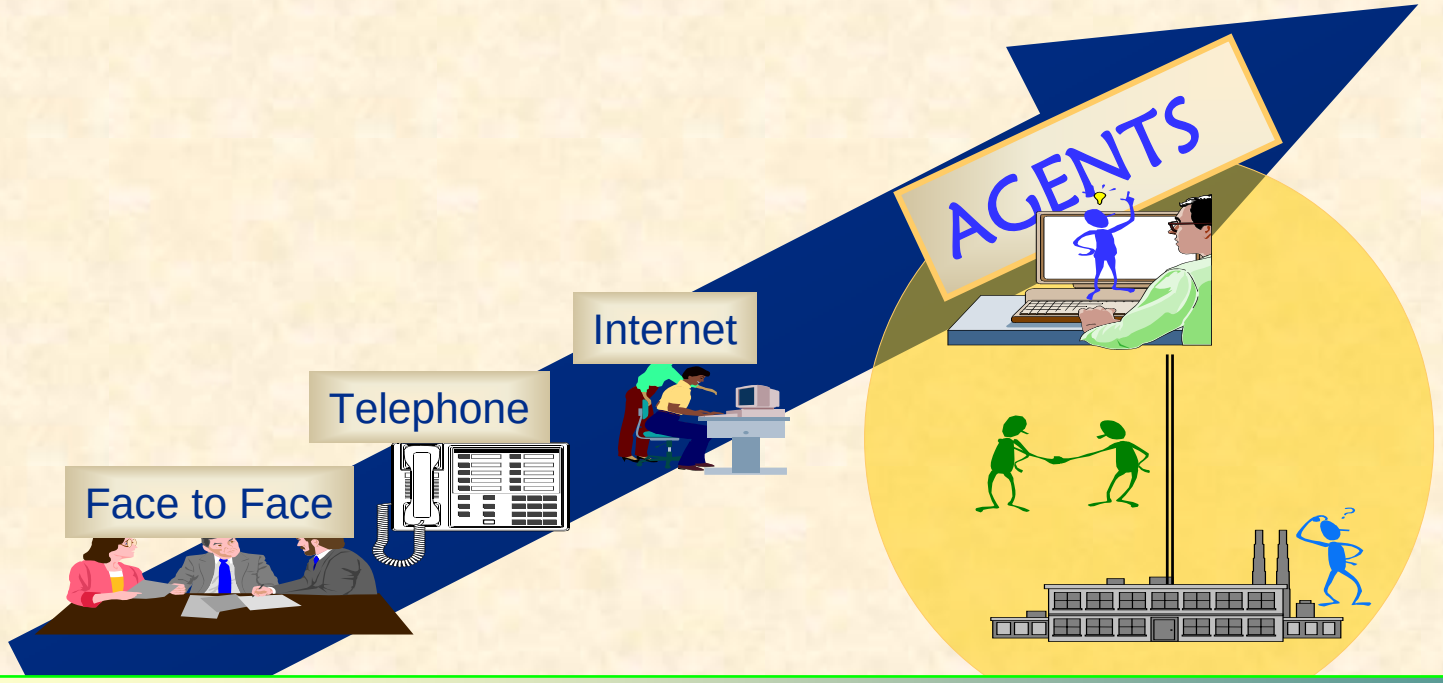
Conference Leadership

- **Hawaii International Conference on System Sciences (HICSS)**
  - **Semantic Web and Software Agents Workshop**
  - **Chairs: Mark Elmore, Tom Potok,**

    ORNL Software Agent Researchers

- **DHS Text Analysis Workshop**
  - **Organizer: Tom Potok, ORNL**
  - **Organizing Committee Member: Mark Elmore**

Agent Technology Trend



"The Semantic Web… will open up the knowledge and workings of humankind to meaningful analysis by ***software agents***, providing a new class of tools by which we can live, work and learn together"

Tim Berners-Lee, James Hendler, Ora Lassila

"The Semantic Web" Scientific American 5/2001

What are Agents?

Some (of many) "classic" definitions

...Software entities that *assist people and act on their behalf*

Adaptive
- have the ability to exist in multiple environments

Goal-driven
- have a purpose and act in accordance with that purpose until it is fulfilled

Communicative
- able to interact and communicate with users and other agents

Reactive
- detect changes in their environment and react to those in a timely manner by answering to events and initiating actions

Autonomous
- can have control over their own actions and be able to work and launch actions independent of the user or other actors

What Names Do Agents Go By?

Some (of many) names

- Autonomous Intelligent Agents
- Empowerment Agents
- Software Agent Technology
- Intelligent Software Agent Technology
- Software Agent Paradigm
- Software Agents

Buzz Word Generator

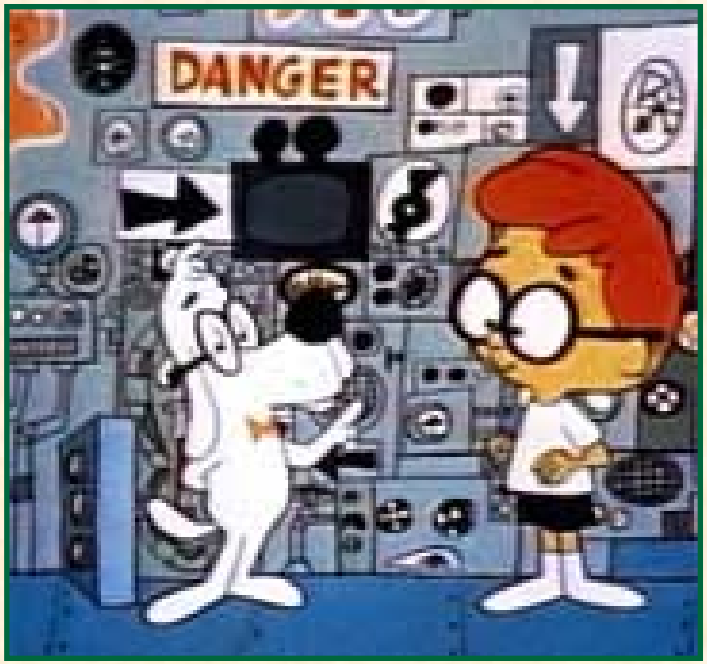
(Using Backus-Naur Form or BNF)

```
 buzz-word ::= <prefix> <agent> <postfix>
     agent ::= “agent” | “agents”
    prefix ::= <fancy-word> | <prefix> <fancy-word>
fancy-word ::= “autonomous” | “empowerment” | “intelligent” |
               “mobile” |  “multi-” | “software” | ...
   postfix ::= “technology” | “paradigm” | “”
```

Some (of many) Related Buzz Words

- **ACL:** Agent Communication Language
- **FIPA:** Federation of Intelligent Physical Agents
- **GIG:** Global Information Grid
- **KIF:** Knowledge Interchange Format
- **KQML:** Knowledge Query and Manipulation Language
- **RDF:** Resource Description Framework
- **Semantic Web:** The web Tim BL would have invented?
- **SOA:** Service Oriented Architecture
- **SOAP:** Simple Object Access Protocol
- **WSDL:** Web Services Description Language
- **UIMA:** Unstructured Information Management Architecture
- **XML:** Extensible Markup Language

Mark's Fractured History of Computer Science



- **1940s: Hardwired, Mechanical**
  - RADM Grace Hopper's Computer Bug
- **1950s: Machine Code, Assemblers**
- **1960s: Linear Programming**
  - "Spaghetti Code"
  - Edsgar Dijkstra's goto-less breakthrough
- **1970s: Procedural Programming**
  - Ken Thompson *(wife: Bonnie)* : B
  - Brian Kernighan and Dennis Ritchie: C
- **1980s: Object-Oriented**
  - *Modeling interactions between Real-World Objects*
  - ADA and SmallTalk
  - Bjarne Stroustrup: C++
- **1990s: World Wide Web**
  - Sun's James Gosling *brings O-O to the forefront*: Java
- **2000s: Agent-Oriented**
  - *Modeling interactions between PEOPLE!*

Object Oriented Programming

- **Encapsulation: Objects tie processing to data**
- **The idea of [Agents] departs significantly from that of object-oriented (O-O) programming**
  - **O-O strongly suggests binding data and its processing together**
- **So, in O-O programming style**
  - **Every CD would come with its own player**
  - **And they are not supposed to be separated.**
- **As odd as this sounds**
  - **This the way we have built many software systems**

~Hao He

Agents, on the other hand

- **Separate processing and data**
- **And separate the hardware they run on**
- **In the CD analogy**
  - **CDs could play on multiple CD players**
  - **And you may take a CD and a CD player to a number of locations**
- **With Agents**
  - **Processing Agent**
  - **Meets Data Agent**
  - **At Agent Host with sufficient compute power**

This Meeting Is An Agent Example

- **We didn't have to know ahead of time**
  - **Who specifically would show up**
  - **What the specific facilities would be**
  - **Or even what the specific topics would be**
- **And these can change throughout the meeting**
- **Yet we work together**
  - **Generating the best solution given the capabilities present**

An Evolving Definition of Agents

- **Agents solve problems based on how humans solve problems**

- **Two key questions**
  - **If I had enough humans, how would I solve the problem?**

    — or —
  - **Can I think of an example of how humans have solved this problem?**

A Simple Agent Example

Agent, find me the book "War and Peace," and I need it tomorrow

Does the agent understand buying books?

Form a plan to buy the book

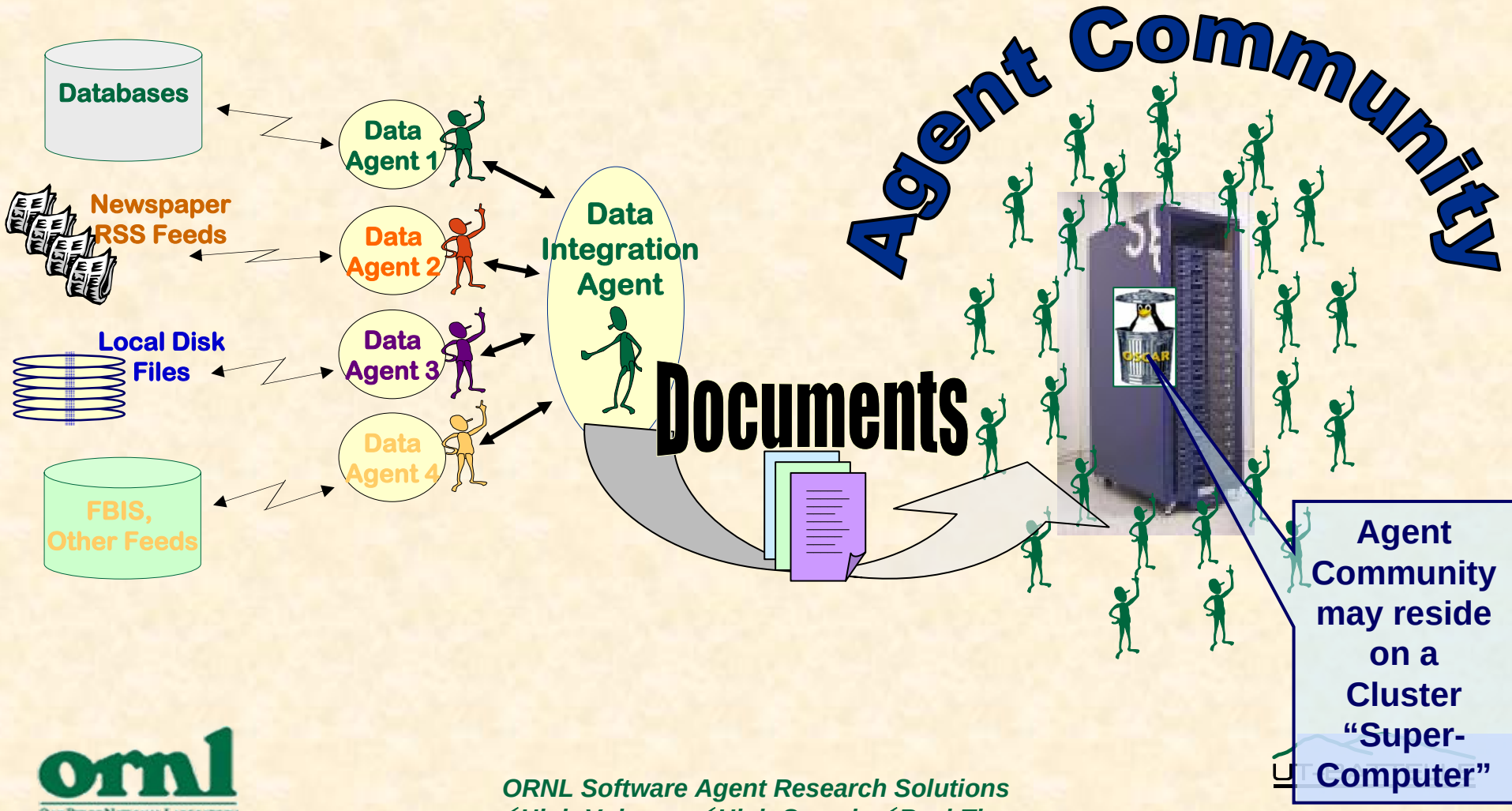
Execute the plan

Amazon	2 Days $18.50
Barnes and Nobel	1 Day $21.75
B. Dalton	1 Day $20.25
Library	1 Day Free
eBay	1 Day $12.50
On-Line www.online-literature.com	Free

Real World Example

- **Need to gather documents from a variety of sources**
- **Need to organize documents for rapid understanding**
  - **But even a computer is not fast enough for the volumes of data**
  - **How can this task be spread across multiple computers?**

Diverse Documents Enter Agent Community

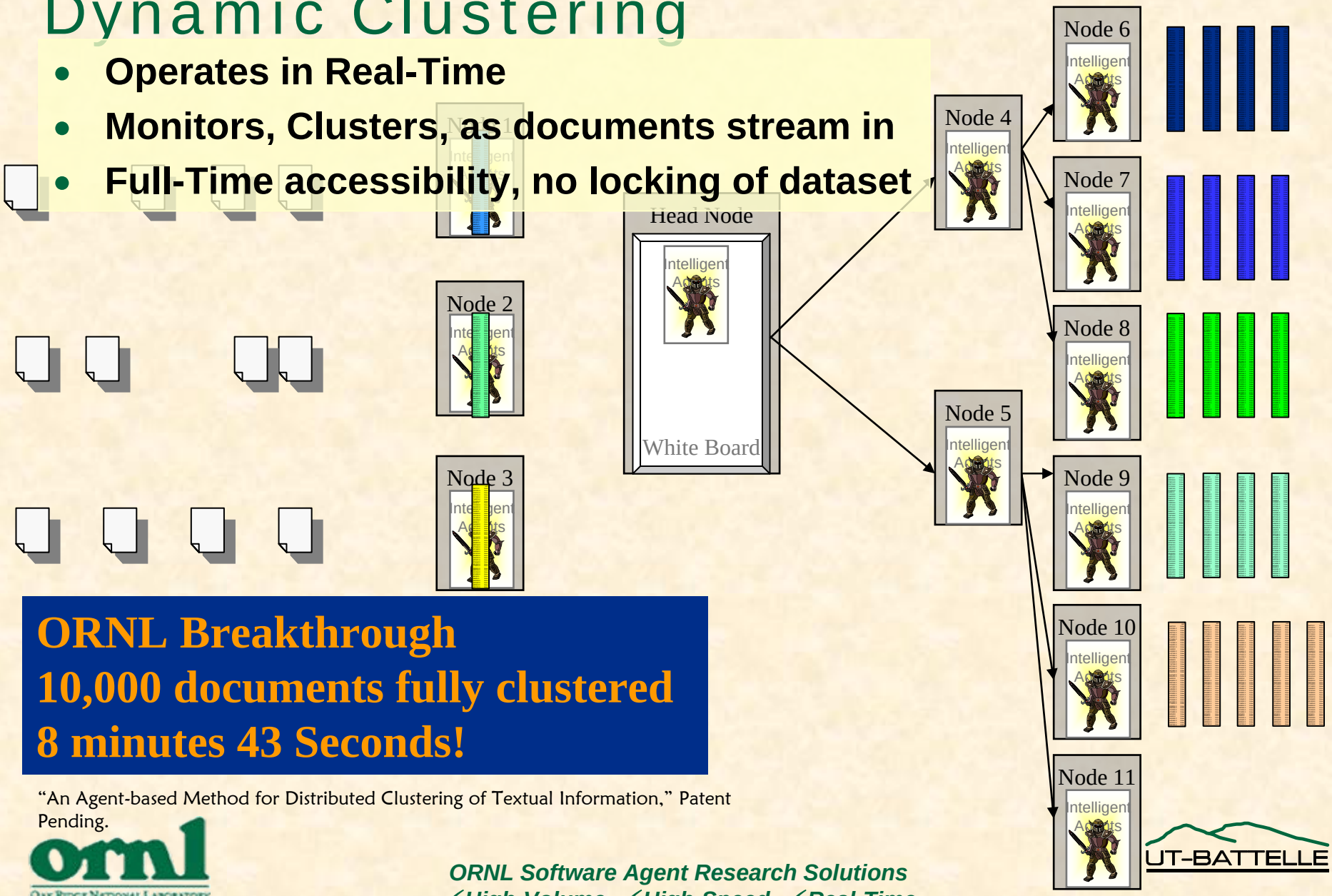


ORNL Software Agent Research Solutions
✓High-Volume ✓High-Speed ✓Real-Time

Mark Elmore

Piranha: Agent-based Distributed Dynamic Clustering

- **Operates in Real-Time**
- **Monitors, Clusters, as documents stream in**
- **Full-Time accessibility, no locking of dataset**



ORNL Breakthrough
10,000 documents fully clustered
8 minutes 43 Seconds!

"An Agent-based Method for Distributed Clustering of Textual Information," Patent Pending.

ornl Oak Ridge National Laboratory

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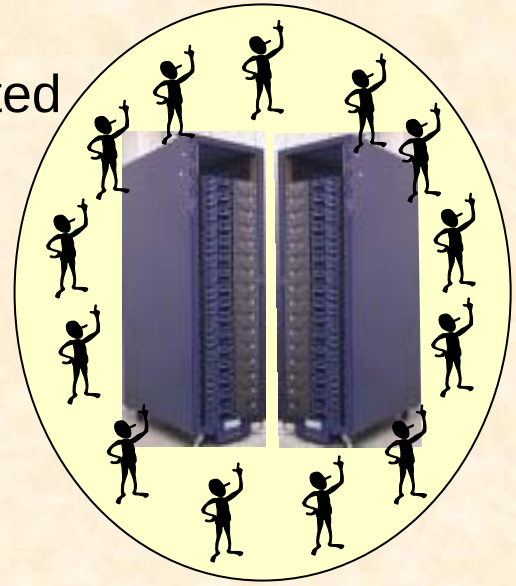
Software Agents & High Performance Computing Research

Joint Intelligence Center, Pacific (JICPAC)

- **JICPAC Clusters**
  - **ORNL designed, built, and managed**
  - **Red-Oak / White-Oak Twin Clusters**
    - **Full-on screamers!**
    - **For high-end Agents-On-Clusters research**
    - **Newest, most powerful cluster computers in ORNL stable**
  - **Acorn mini-cluster**
    - **Research into capabilities in low-infrastructure environments**

Unparalleled Capability: Dynamic Text Analysis

- **Breakthrough:**
  - ORNL Software Agents Coordinating Distributed Collections
- **Result:**
  - Software Agents can now organize larger document sets by using multiple computers
    - Agents can cooperate across network distributed machines
    - Empowers Software Agents To Harness High-Performance Cluster Computing
    - High-Volume, High-Speed, Real-Time Solutions



Web Developer's Future Role? 1

- **Can Agents more easily find documents?**
  - **Web services that not only present data**
    - **But describe the data presented**
  - **Pointers (that can be understood by agents) to other documents**

Web Developer's Future Role? 2

- **Can the documents be marked up before posting?**
  - **While HTML marks up for viewing**
  - **XML (and deriviatives) marks up for content**
    - **What is an author, a title, a date, a location?**
  - **RDF, OWL, other SemWeb tech marks up for *meaning***
    - **Is a bomb**
      - **A bad play on Broadway?**
      - **A long football pass?**
      - **A great looking car? (or a bad looking car?)**
      - **Or a terror-based explosion to be thwarted?**

- **Currently, there is a great amount of effort that adds needed markup *after* a document is posted**

Web Developer's Future Role? 3

- **Can Web Services offer tools to process data?**
- **Can Web Services offer computing platforms where processing and data can meet?**

A Prediction

- **Web Developers will facilitate this new paradigm**
- **No longer will National Labs operate in isolation of one another**
  - **Not if they want research funding!**
- **Collaboration across the National Labs will be the New Order**
- ***Web developers will be there where the rubber meets the road!***

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