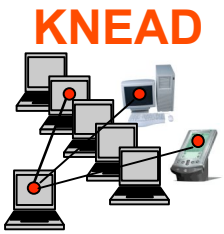


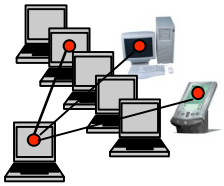

# Knowledge Exploration, Analysis, and Discovery (KNEAD) Challenge Workshop

Mark Maybury
Penny Chase
The MITRE Corporation

DFRWS
15 August 2006

CIIS Center for Integrated Intelligence Systems MITRE

KNEAD



# Workshop Objective

**To identify tools and methods to enable groups of interdisciplinary forensic analysts to organize, access, and "mine" maximally relevant information from large volumes of continuously changing multimedia, multilingual, and multicultural data**

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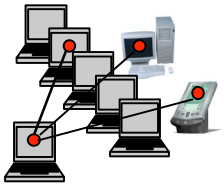

# Workshop Approach

- Bring together a cross-disciplinary group of experts from academia, industry, and government
- Two-day meeting at MITRE McLean, November 15 and 16, 2006
  - First day
    - Micro-problem
    - Macro-problem
    - Participants gave presentations on what contributions their disciplines bring to the problem
  - Second day
    - Focused on key issues that emerged during first day
    - Developed recommendations
- "Virtual Workshop"
  - Results were refined over several months
  - Small groups worked on different topics, collaborating via email, telecons, and face-to-face meetings

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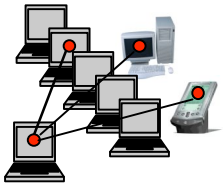

# Participants

- Brian Carrier (Purdue)
- *Brant Cheikes (MITRE)*
- Jeremy Christianson (IRS)
- *Chris Elsaesser (MITRE)*
- LeeEllen Friedland (MITRE)
- Susan Fussell (CMU)
- Jessica Glicken Turnley (Galisteo Consulting Group)
- Paul Kantor (Rutgers)
- *Sara Kiesler (CMU)*
- *Michael Ledeen (AEI)*
- *Laura McNamara (Sandia)*
- Sue Lee (JHU APL)
- Flo Reeder (MITRE)
- Fred Roberts (Rutgers)
- *Eugene Spafford (Purdue)*
- *Frank Stech (MITRE)*
- Sarah Taylor (LMCO)

***Participated in workshop follow-up***

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# Micro and Macro Problems

- Micro-problem
  - Hands-on experiment
  - Small, interdisciplinary groups
  - Problem: what can you tell us about a single disk drive?
- Macro-problem
  - Thought experiment
  - Problem: what happens when you try to scale to 100s or 1000s of data collections?

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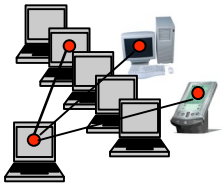

# Data Characteristics

- Massive
  - Volume
  - Complexity
- Multimedia
  - Data, Text, audio, image, etc.
  - Structured, unstructured, semi-structured
- Multilingual
  - Data is not just in English
  - A single document could be in multiple languages
- Multicultural
  - Multiple cultural backgrounds and cognitive styles of the data's users and creators
- Multiscale
  - Document to drive to computer to network
- Streaming
  - Non disk resident
  - Might require real-time analysis
- Heterogeneous Purposes
  - Investigative, tactical, strategic
- Analysis Techniques Evolve
  - Analysis results change
- Denial & Deception
  - Intentionally hidden or distorted data

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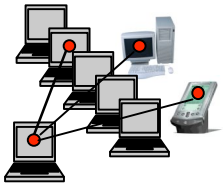

# Data and Information Discovery

- **Findings**
  - **Must scale from 1 to 100s to 1000s of devices/sources**
  - **Need for both top-down and bottom up processing**
  - **Need to semi-automatically determine relevant & important information in a constantly evolving environment**
- **Recommendations**
  - **Address scale**
    - **Investigate iterative, adaptive approaches**
    - **Explore methods that *benefit* from scale**
  - **Explore models of background noise**
  - **Consider time value of data, observables, hypothesis, confidence**
  - **Explore personalized information organization**
  - **Develop contextual processing and "culturally aware NLP", e.g., discourse, attitudes/opinions, hidden meaning, and identity, social relations, and status**
  - **Develop technologies to incorporate qualitative data into computational social simulations**
  - **Develop continuum of confidences from multiple data and processing**

# Architecture and Tools

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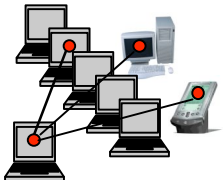

- **Findings**
  - Complexity of data, tools and processes requires interoperability, fusion, plug and play, reuse
  - Discovering “optimal” tool and process combinations requires multiperspective evaluations (e.g., technical, cognitive, psychological, and socio-cultural)
  - Flexibility and extensibility over time is necessary to support new data types, processing methods, and human tasks
- **Recommendations**
  - Support analyst centered processes
  - Explore emergent and adaptive systems to address complexity in the data, from analysts, in target sets
  - Explore architectures that naturally support analyst collaboration and contextual enhancement of analyses

# Analysis

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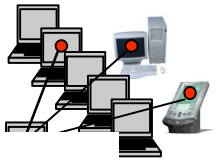

- **Findings**
  - Meaning is not inherent in the data, but is brought to the data by the analyst
  - Methodologies to capture, account for, and communicate (potential) biases are poorly developed
  - Data is incomplete (aleatory uncertainty) and analyst biases may lead to conflicting interpretations of existing data (epistemic uncertainty)
- **Recommendations**
  - Involve analysts in R&D up front
  - Explore analysis of analysis, e.g., tasks, methods, tools
  - Support multiple levels of analysis
  - Seek tools that can fit interchangeably into a multi-brain, asynchronous analytic process
  - Reconceptualize the intelligence process as an iterative and ongoing interaction between data and sensemaking and between computers/tools and human
  - Create tools that allow analysts to manipulate ontologies in real time to formally capture cultural or sensemaking perspectives
  - Create methods to capture and communicate analyst uncertainty (epistemic uncertainty) and data uncertainty (aleatory uncertainty) to enhance clarity of output.

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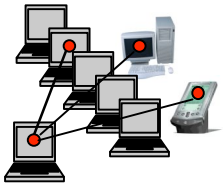

# Collaboration

- **Findings**
  - **Collaboration is an essential ingredient to leverage multiple perspectives and ensure reuse.**
  - **Effective analysis must include social, cultural, and behavioral context.**
  - **Variances in skill, experience, confidence**
- **Recommendations**
  - **Engage social, organizational, and behavioral scientists to understand motivation, human and group dimension/dynamics**
  - **Develop anthropological perspectives**
  - **Develop a continuum of confidences arising from multiple analysts**
  - **Investigate collaborative teams of hunters, gatherers, and explorers**
  - **Explore cross discipline/perspective collaboration**
  - **Leverage historical analysis (group, situation)**

# Collaboration

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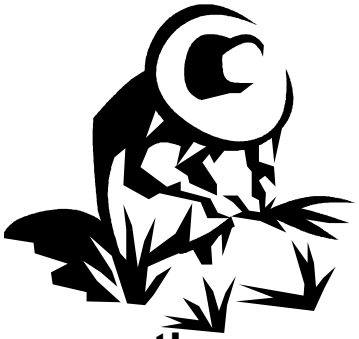
**hunter**

- chase moving targets
- specialized tools to extend range and effectiveness



**gatherer**

- collect stationary objects
- known, fixed locations
- known times

**explorer**

- map unknown territory
- react opportunistically
- navigation/transportation

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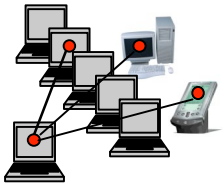

# Evaluation

- **Requirements**
  - **Results must be valid, reliable, and objective**
    - **Metrics should be simple to specify and straightforward to measure**
    - **Replicable and ideally automatable to support evaluation of large data sets**
    - **Independent of (natural) language, theory, and development paradigm**
  - **Process must be cost-effective across resource dimensions (time, cost, data, human)**
  - **Results must be useful to the consumer of the evaluation (users, developers, program managers)**
- **Leverage prior work**
  - **EAGLES (Expert Advisory Group for Language Engineering Standards) task-based approach**
  - **Task-based cross-evaluation (initially developed for DARPA AntWorld project and refined for AQUAINT)**

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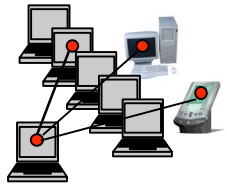

# Summary Findings and Recommendations

- Solutions must address the need to scale, reduce noise, process heterogeneous sources, support multidisciplinary analysis, and manage uncertainty
- Research must be driven by realistic data and analysts/operators
- Research and analysis must be iterative and rapid
- Small experiments are necessary to converge on progress
- Both unclassified and classified/sensitive data sets are needed to effectively evaluate performance of tools and methods

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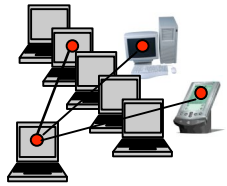

# Summary Findings and Recommendations

- Employ multidisciplinary research teams (including ethnographers, psychologists, computer science, domain experts)
- A "jump start" demonstration would accelerate progress
- Augment existing programs to advance KNEAD-specific gaps
- Areas for further research
  - Scaleable forensics
  - Contextual and cultural processing to enhance signal from noise (in an evolving haystack)
  - Collaborative, multiperspective analysis (awareness, annotation, discovery, and debate)
  - Exploring forensic hypotheses under uncertainty
  - Tailorable analytic environments

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