The Homeland Security Center for Dynamic Data Analysis at Rutgers University

AT&T Labs – Research
Bell Labs/Lucent Technologies
Princeton University
Rensselaer Polytechnic Institute
Rutgers, the State University of New Jersey
Texas Southern University
Texas State University, San Marcos

History

- 2006: The Center for Dynamic Data Analysis (DyDAn) is created and is named a Department of Homeland Security "university center of excellence"

- DyDAn is one of four DHS centers dealing with "discrete science"

- Other centers: Univ. of Illinois Urbana-Champaign, Univ. Southern Cal., U. Pittsburgh

- DyDAn is the "coordinating" discrete science center.

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What is Discrete Science

- Discrete Science deals with
  - Patterns
  - Arrangements
  - Assignments
  - Schedules
- Discrete Science
  - Seeks patterns in large amounts of data
  - Analyzes connections between entities such as people and groups
  - Develops efficient ways to quickly spot changes in standard patterns

DyDan

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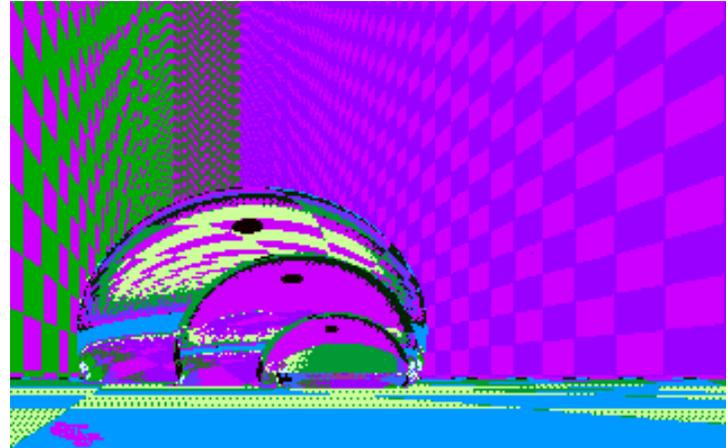
Why DyDAn?

- Homeland Security requires inferences from massive flows of data, arriving continuously.

- Buried in data are: quickly changing patterns.

- DyDAn: *is developing novel technologies to find patterns & relationships in dynamic, nonstationary, massive datasets.*

- DyDAn: *is producing pioneering educational programs to nurture the homeland security workforce of the future*

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Why DyDAn?

- *Much of DyDAn's work is relevant to port security problems:*
  - Data from container inspection
  - Radiation portal monitoring data
  - Algorithms for container inspection
  - Optimal allocation of funds for protection of port infrastructure
  - Risk assessment

DyDAn Application Areas

- DyDAn methods are applicable to a wide variety of homeland security applications.

  – **Intelligence Analysis of Text**

  – **Disease Event Detection**

  – **Port of Entry Inspection**

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DyDAn Application Areas

- DyDAn methods are applicable to a wide variety of homeland security applications.

  - **Author Identification**

  - **Response to Natural Disasters**

  - **Bioterrorism**

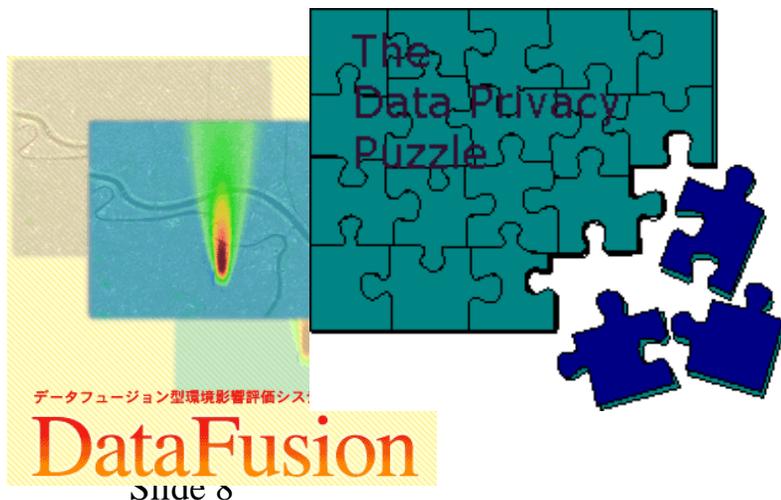   **Sensor Location**

B-T sensor,
Salt Lake
City Olympics

Slide 7

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DyDAn Application Areas

- DyDAn methods are applicable to a wide variety of homeland security applications.
  - **Protection Against Invasive Species**
  - **Customs and Border Protection**
  - **Privacy-Preserving Data Sharing**

Three Invasive Species

Mark Humphrey / AP file

The Data Privacy Puzzle

DataFusion

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DyDAn

DyDAn Researchers Work On:

- Counter-terrorism

- Intelligence analysis

- Disease surveillance (natural/man-caused)

- Customs and border protection

- Law enforcement

- Data management in emergency situations

- Nuclear detection/sensors

- Image, audio, text, gait analysis

Avian flu

Containers for Inspection

We hope to make DyDAn an informatics resource for the homeland security enterprise

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DyDAn Research

- Three research themes:
  - **Analysis of Large, Dynamic Multigraphs**
  - **Continuous, Distributed Monitoring of Dynamic, Heterogeneous Data**
  - **Applications to Real Homeland Security Problems**

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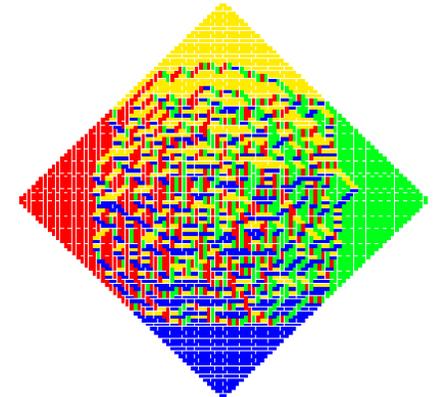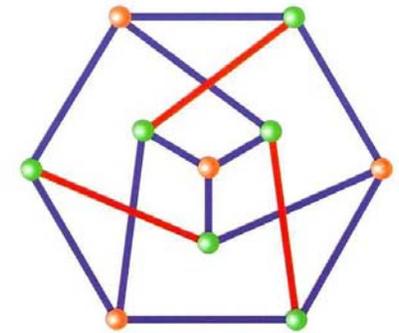
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DyDAn Research I: Analysis of Large, Dynamic Multigraphs

- Need to understand interactions between entities: people, objects, groups

- Interactions often modeled as *graphs*
  - Linking nodes (entities) with edges (connections)

- Multiple relationships between entities suggests *multigraphs*

- Add new entities, new & changing connections suggests *dynamic multigraphs*

- Develop methods to represent, analyze, interrogate, & navigate dynamic multigraphs.

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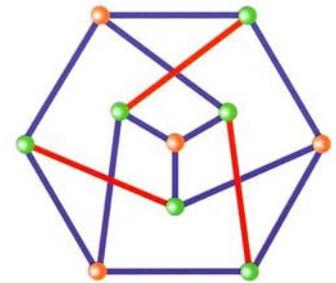
DyDAn Research II: Continuous, Distributed Monitoring of Dynamic, Heterogeneous Data

- Need to understand *massive* amounts of data.
- Data inherently *distributed* (multiple sources)
- Data arrives rapidly – "*continuously*"
- Seek anomalies, patterns, "*emerging events*"
- Run *continuous queries* to monitor incoming data stream.
- Data takes *numerous forms*; requires data mining methods that span the modalities.

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DyDAn Research III: Applied Work

- Builds on earlier work at Rutgers on
  - Port security
  - "Monitoring message streams"
  - Locating bioterrorism sensors
  - Syndromic surveillance
- Works with
  - Coast Guard
  - DNDO
  - Port Authority of NY/NJ
  - NJ Office of Homeland Security and Preparedness
  - CDC
  - Intelligence community

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DyDAn Research Portfolio I: Large Graphs

- Universal Information Graphs
- Adding Semantics to and Interconnecting Semantic Graphs
- Statistical and Graph-theoretical Approaches to Time-Varying Multigraphs
- Analyzing Large, Dynamic Multigraphs Arising from Blogs

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DyDAn Research Portfolio II:
Monitoring of Dynamic, Heterogeneous Data

- Optimization and Learning
- Privacy Preserving Data Analysis

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DyDAnResearch Portfolio III: Some Applied Topics

- Uses of Entropy in Biosurveillance (with MSI's Howard and Morgan State)

- Enabling and Enhancing Crime Prevention and Analysis at the Port Authority of NY&NJ (with PANYNJ & PNNL & START)

- Algorithms for Container Inspection in Ports (sponsored by ONR, NSF)

- Sensor Management for Nuclear Detection (funded by Domestic Nuclear Detection Office) (collaborations with LANL, PNNL, Sandia)

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DyDAn Data

- Emphasis on publicly available data.
- Research on how to acquire, publish, analyze, store data in a private, secure way.
- Research on privacy-preserving data analysis.
- **Director of Data Analysis** works on all aspects of acquiring, sharing, publicizing analyzing data: privacy, legal, technical, etc.

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DyDAn Educational Programs

- We have initiated educational programs from K-12 to postgraduate

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Workshops: Sample Topics

- Semantic Graphs Computational Methods for Dynamic Interaction Networks

- Mathematical and Computational Methods for Information Security

- Privacy-Preserving Data Analysis

- Secure Internet Routing

- Climate and Disease

- Disease Clusters

- Internet Tomography

- Network Models of Biological and Social Contagion

- Streaming, Coding, Progressive Sensing

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Training Programs, Tutorials, Shortcourses

- **"*Reconnect*":** for faculty teaching undergraduates and government employees seeking new areas of expertise
  - Data Analysis in Law Enforcement and Homeland Security (August 2007)
  - Biosurveillance (June 2008)
  - Visual Analytics (Summer 2009)

- *Tutorial*: Statistical De-Identification of Confidential Health Data (April 2009)

Law enforcement: Situational awareness

Anthrax

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Other Educational Programs

- *DHS Scholars and Fellows Program:* Funding 6 Graduate Student Fellows at Rutgers

- *DHS MSI Summer Research Program:*
  - Biosurveillance
  - (Howard, Morgan State): Summer 2007
  - Another opportunity for summer 2009

- *Research Experiences for Undergraduates*
  - Since Summer 2007
  - Students study 1-on-1 with DyDAn mentor
  - Students from all over the U.S.
  - Projects planned for Summer 2009

- *Internships:*
  - At Rutgers, Bell Labs, & with national lab partners

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Other Educational Programs

- *High School Teacher Program:*
  - Theme: Discrete math and homeland security
  - Connecting homeland security research to the classroom

- *Middle School Program:*
  - Collaborates with Port Authority Project
  - Development of written materials to be usable in classrooms
  - Pilot testing of materials and teacher training to use them

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The Homeland Security Center for **Dynamic Data Analysis** at Rutgers University

The numerous applications of discrete science form the basis of DyDAn's work.

We look forward to partnering in numerous DHS applications.