Data Utility in Science Decision-Making

Ken Galluppi

Director, Disaster and Environmental Program

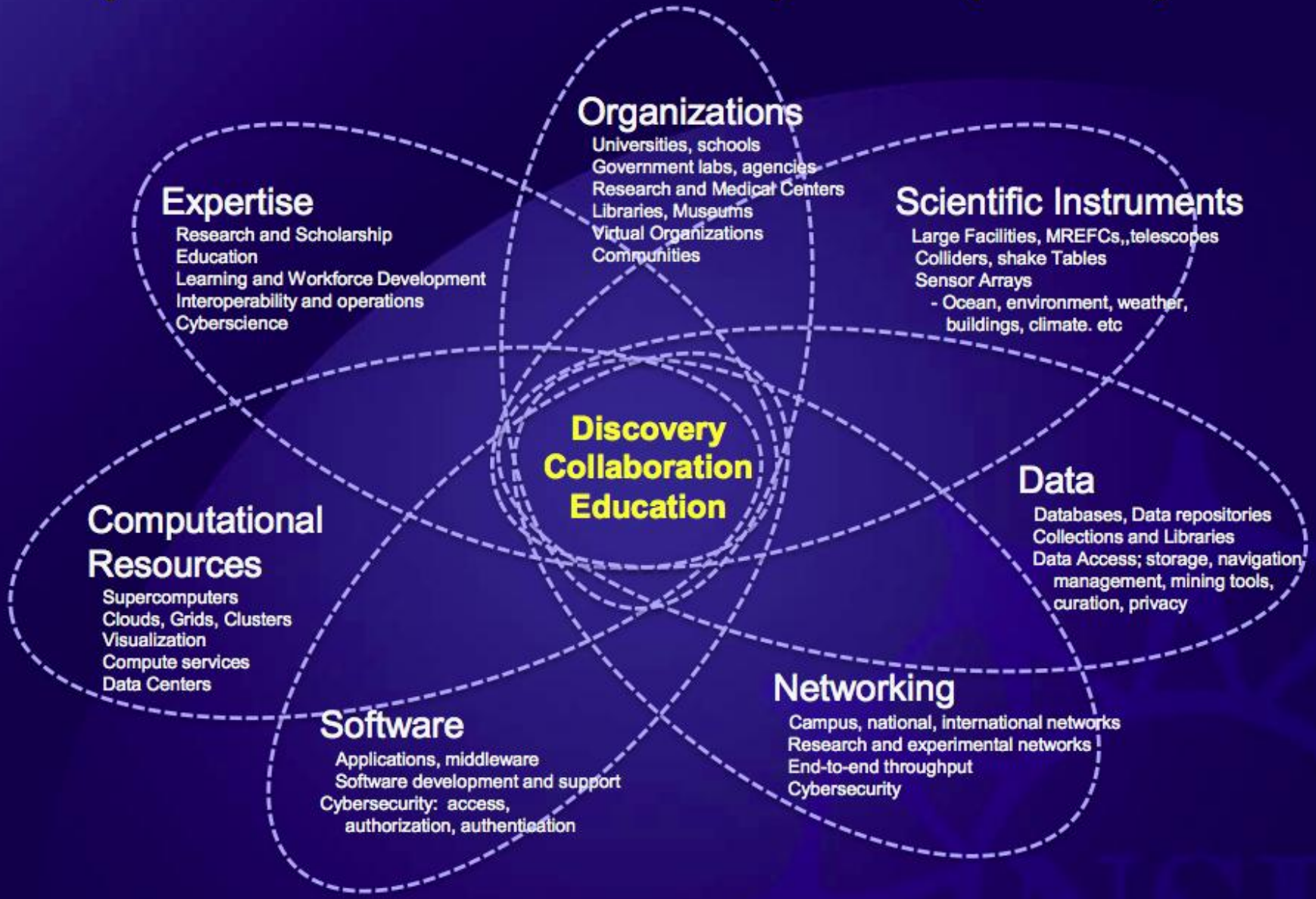
renci

RESEARCH \ ENGAGEMENT \ INNOVATION

Framing the Challenge: Science and Society Transformed by Data

- Modern science
  - Data- and compute-intensive
  - Integrative, multiscale
- Multi-disciplinary Collaborations for Complexity
  - Individuals, groups, teams, communities
- Sea of Data
  - Age of Observation
  - Distributed, central repositories, sensor-driven, diverse, etc

Cyberinfrastructure Ecosystem (CIF21)



Maintainability, sustainability, and extensibility

“User” General Statements

- The value proposition is not in the science but in the decisions based on science.
- Decision-makers really don’t care about data.
- “Consumers” are becoming more demanding.
- “Providers” need to provide value.
- Value is based on providing context (understanding), knowledge, and confidence.
- Information systems: processing, data streams, data models, data formats, are inadequate.
- Technology outpaces our utility to provide value.

“User” General Statements

To be effective “data” providers,

we must be providers of value to the consumer.

That is, as scientists, we must provide understanding for effective decision making.

Therefore, we must understand the consumers and their decision-making, what knowledge needs they have, and provide that value for solving problems.

With value comes the demand for research, products and services, infrastructure, and sustainability,

Overview

- NWS, Weather for EM
- Decisions and Knowledge
- Context of Knowledge Management
- “Consumers” and “use” patterns
- Cyberinfrastructure for decision services
- Data utility in science decision-making

Weather for EM (WxEM)

- NWS/OST and NOAA/ESRL collaboration on Emergency Management
- Improve risk/crisis management to protect life and property (common purpose)
- Move from data/information provider to one of EM decision support (value)
- Understand the consumer: EM community
- Understand decisions in context to social networks, processes, and I-K-D flow.
- Address changing NWS products and services

Who is the EM Consumer?

Emergency Support Functions	Mitigation	Preparedness	Response	Recovery
#1: Transportation	X	X	X	X
#2: Communications	X	X	X	X
#3: Public Works and Engineering	X	X	X	X
#4: Firefighting	X	X	X	X
#5: Emergency Mgmt	X	X	X	X
#6: Mass Care, Emergency Assistance, Housing, and Human Services	X	X	X	X
#7: Logistics Mgmt and Resource Support	X	X	X	X
#8: Public Health and Medical Svc	X	X	X	X
#9: Search and Rescue	X	X	X	X
#10: Oil and HazMat Response	X	X	X	X
#11: Ag and Natural Resources	X	X	X	X
#12: Energy	X	X	X	X
#13: Public Safety and Security	X	X	X	X
#14: Long-Term Community Recovery	X	X	X	X
#15: External Affairs	X	X	X	X

Traditional focus on Preparedness and Response in ESFs #1-5

Basis for WxEM

Consumer (EM) says about science provision (NWS and NOAA):

- I can’t find it…..
- If I find it, I don’t understand it…..
- If I understand it, I’m still not sure what I am suppose to do about it.

Leads to:

- Fixing it so they can find it:
  - One-stop portals of information
  - Information organized by perceived consumption buckets
- What about understanding? Whose problem is it?
  - Training: expense, how much, consistency?
  - Visual analytics for knowledge conveyance?
  - Changing technology, modes of utility?
- What about context of decisions and actions?
  - Social context
  - Changing technology and modes of utility?

Who are the Decision Makers? The Consumers

- Researchers
  - Seeking new discoveries and understanding
  - Pass along new knowledge (publish and teach)
- Practitioners
  - Have knowledge of problems being addressed
  - Interpret information into problem context
- Managers
  - Seek to understand impacts and consequences
  - Assess and evaluate options for decisions
- Policy Makers or Regulators
  - Objective is to solve a problem, minimize consequences
  - Decide course of action based on recommendations and influences

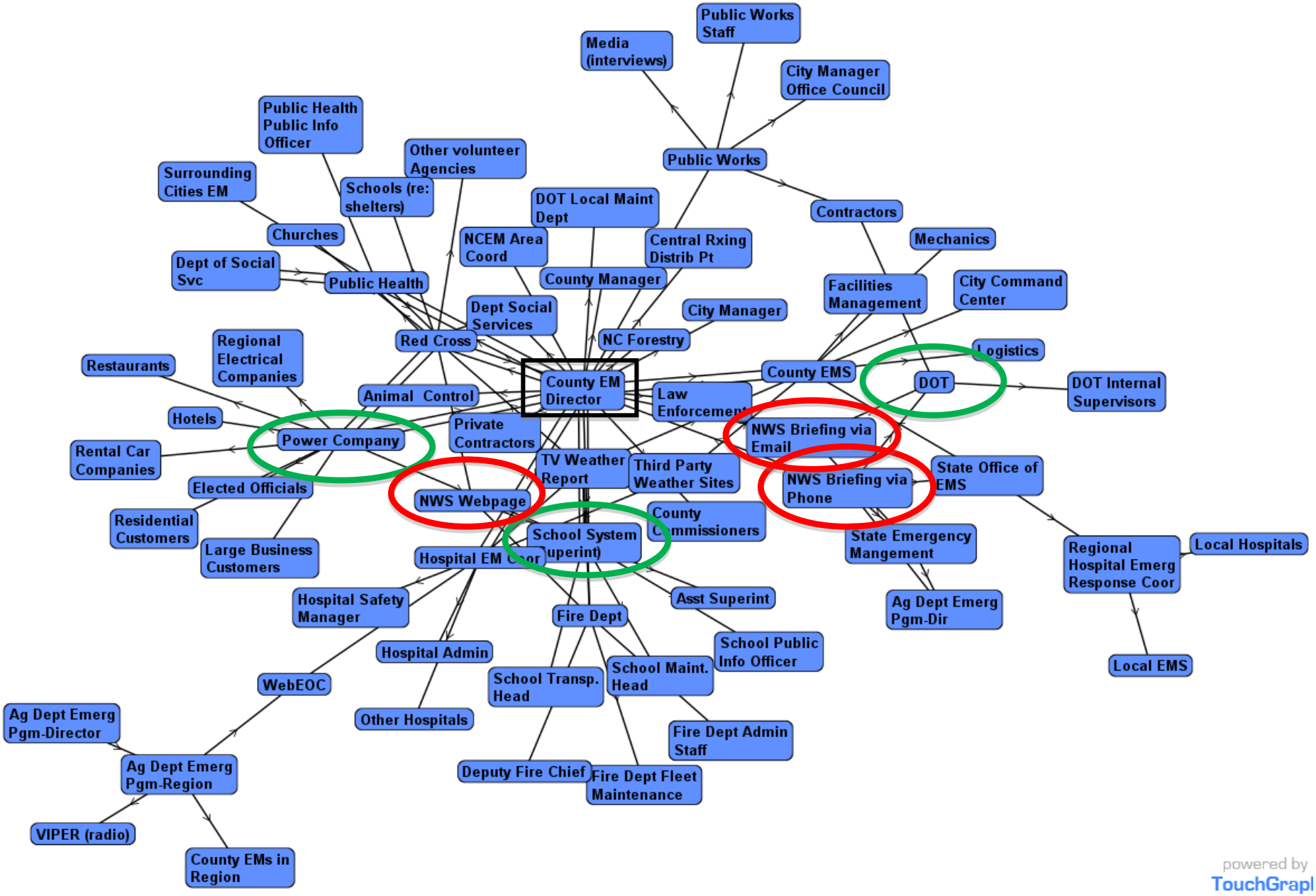
Science Decision Context

- Decisions, based on science, are part of a social network of many actors and purposes.
  - No decision is of itself:
    - Collection of decisions, each requiring knowledge and understanding and information
  - No decision is based on one piece of “information”
    - Other information helps sets the context for understanding
  - No decision is made by a single person in isolation
    - Knowledge has been conveyed by a collection of people
    - Understanding the processes and conveyance is critical
    - The consumer of the decision is not the producer

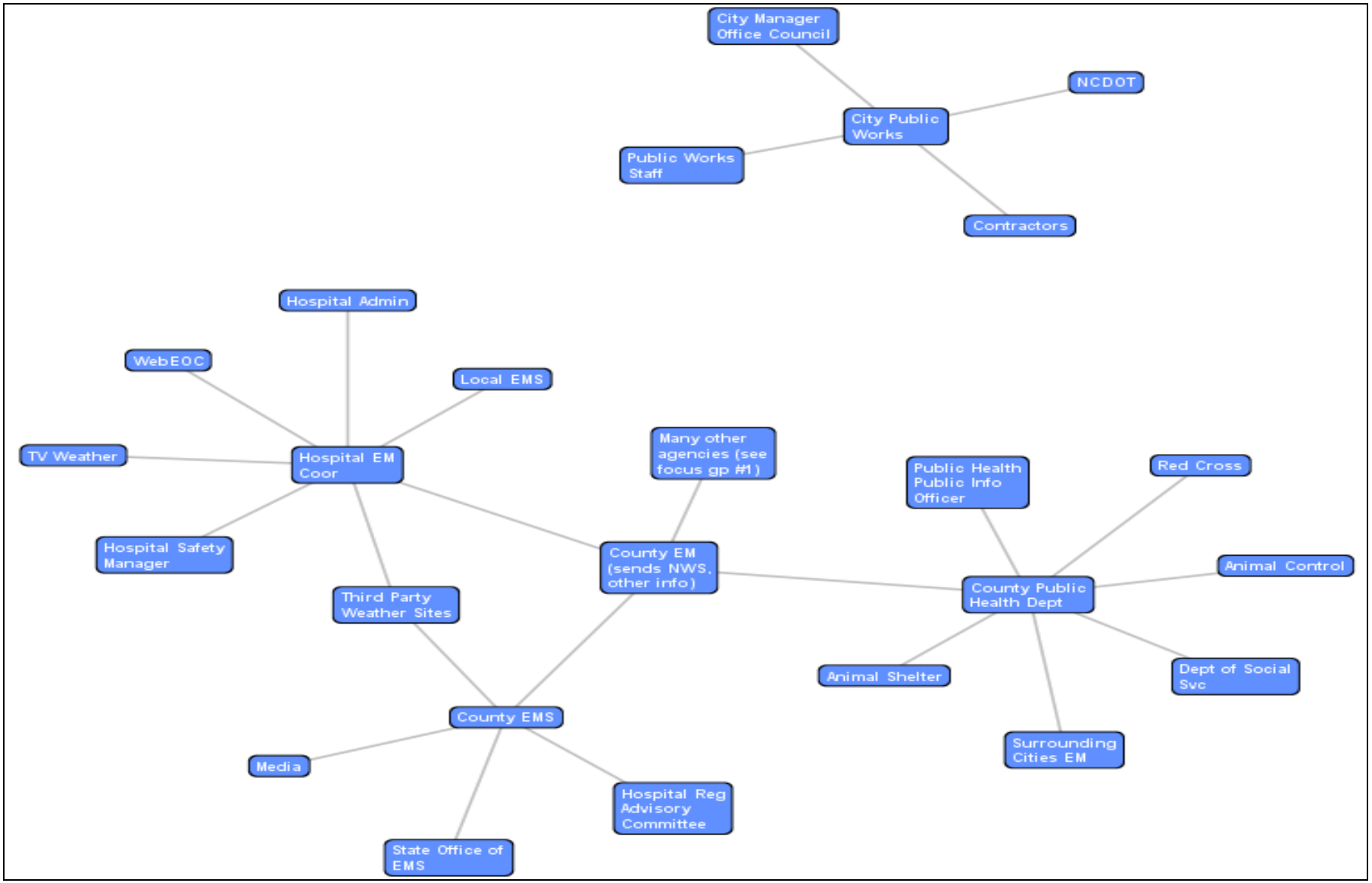
Social Science – Network Analysis

- What decisions and for what purposes?
- Who is in the network, producers and consumers?
- Who are the power brokers, bottlenecks?
- How is knowledge generated and conveyed?
- What do the I-K-D processes look like?
- Is knowledge understood, or assumed to be?
- How to optimize knowledge conveyance?

Simple EM Knowledge Map



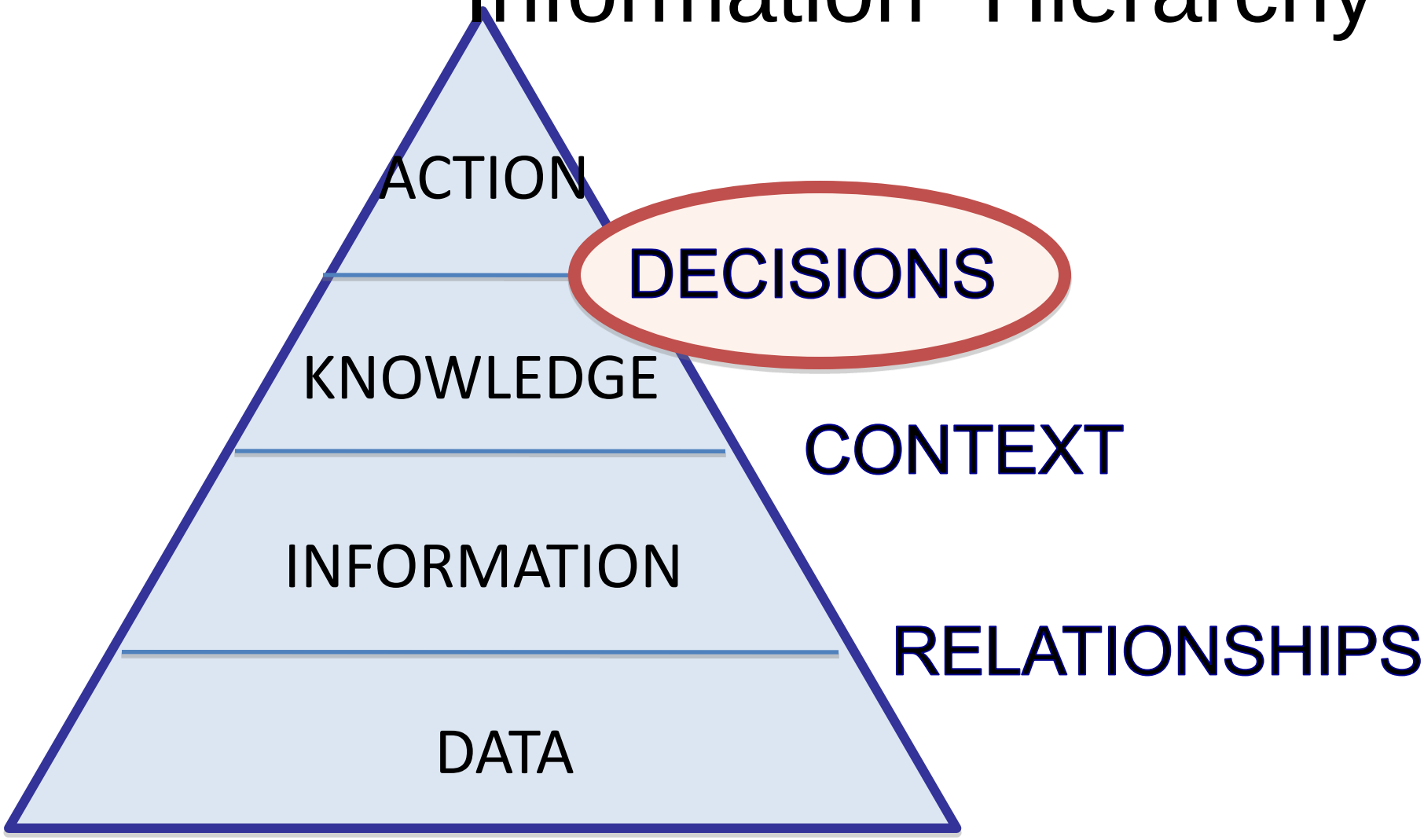
Sub-Group Knowledge Map



Risk Manager Demands

- Decisions are based on knowledge
  - Conveyance: help me <u>understand.</u>
  - Confidence: how sure are you?
- Conveyance demands
  - Derive knowledge for the manager, practitioner
    - Scientists know the science, decision-makers know the action
    - Low tolerance to be trained, “Mohammed and the Mountain”
    - Who are the consumers of decisions (policy)
  - Customized by consumer, based on role, experience
  - Direct to the consumer, cut out the middle-man

“Information” Hierarchy



Knowledge States

Progression	Sample
Datum	5
Information	5 inches of rain
Structured (relationship)	5 inches of rain in Buncombe County since January
Evaluation (context)	Too little rain in Buncombe compared to average need
Judgment (understanding)	Water supply for summer is in danger
Decision (action)	Promote conservation measures now

Holsapple (2008), “Decisions and Knowledge”

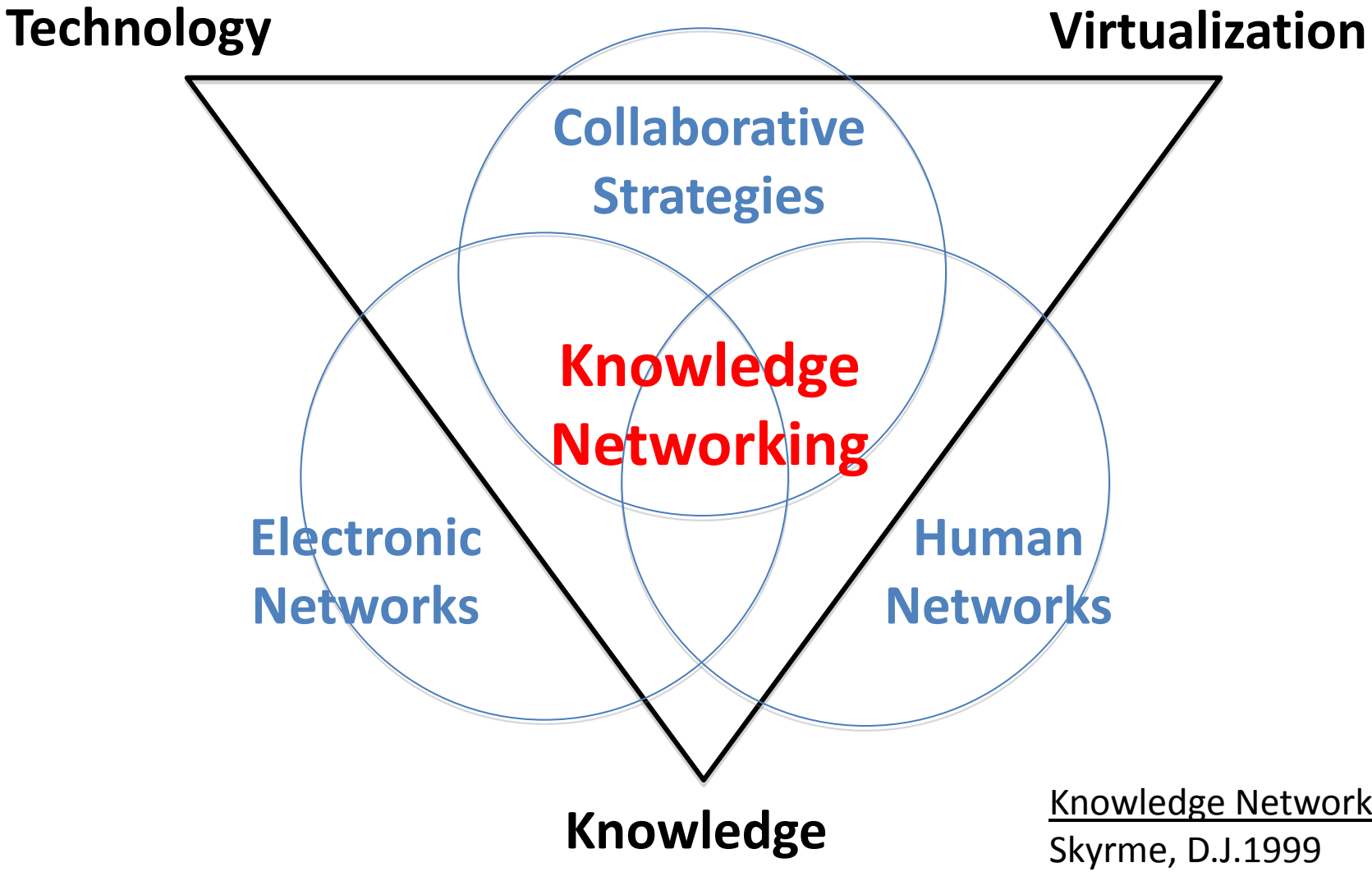
Critical Decision Foundation

- Knowledge
  - Distinguish between I-K-D
    - Information: relationships of data
    - Knowledge: information in context
    - Decision: actions taken to mitigate consequence
  - Optimize the knowledge generation and conveyance
    - Who, when, what, why, where, how
- Confidence
  - Confidence of the decision maker
  - Confidence in the knowledge (uncertainty)

Knowledge Management

- Knowledge
  - Tacit
  - Implicit
- Virtualization
  - Conceptual understanding
  - Situational understanding (awareness)
- Technology
  - Information systems
  - Cyberinfrastructure

Knowledge Networking



Knowledge Networking
Skyrme, D.J.1999

Consumers and “Use” Patterns

- Reality is that consumers use I-K-D flow in daily processes.
- How to go from <u>I to K to D</u>
  - Critical to know the context of science utility
- What are the patterns of “use” of I-K-D?
- Capture the patterns
  - What services are needed?
  - What collection of services make up a pattern
  - How do the patterns change by role or need
  - How does technology influence a pattern?

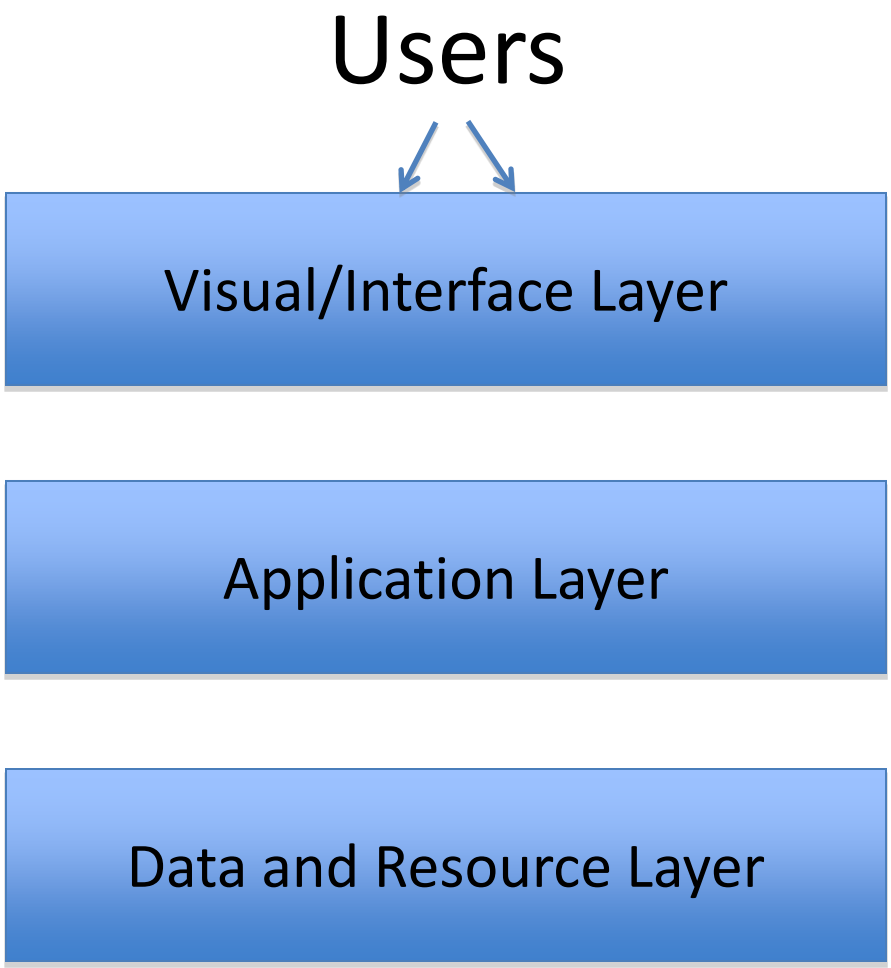
Examples of Decision Patterns

- Pull-Consume-Produce
  - Locate data
  - Pull to location
  - Process by workflow
  - Create product
  - Save/archive
  - Disseminate
- Pull-Evaluate-Decision
  - Locate data
  - Locate second data
  - Compare/evaluate
  - Make judgment
  - Post decision

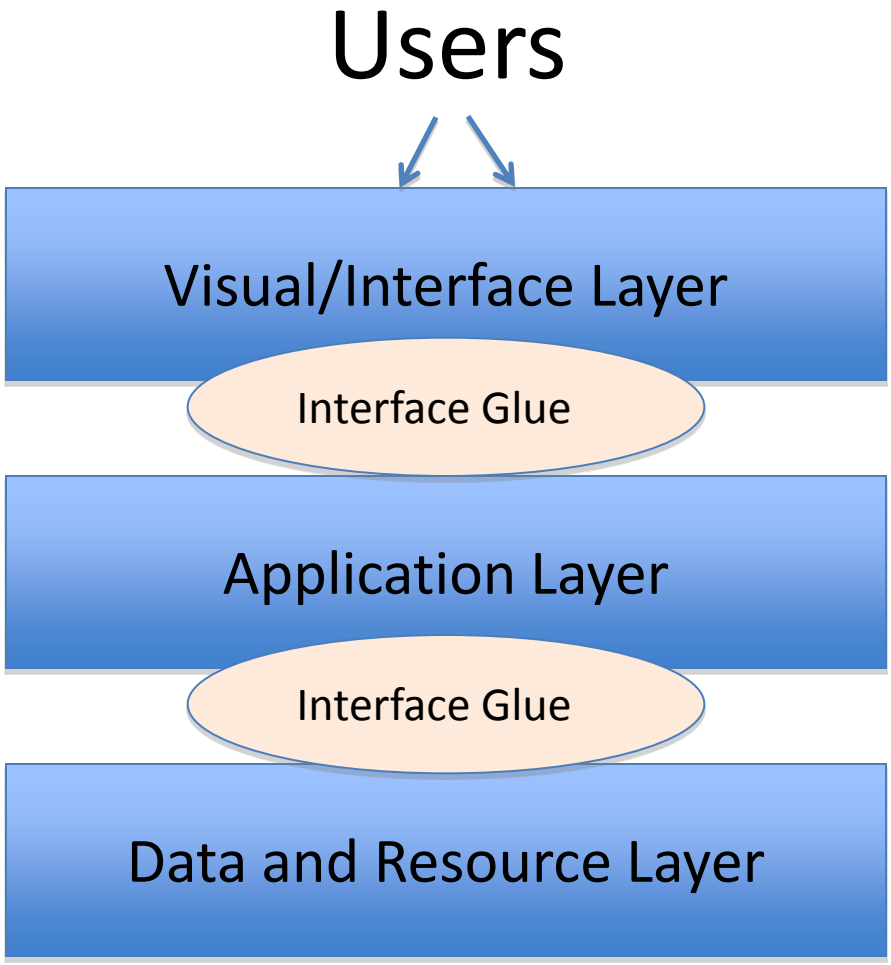
Examples of Decision Patterns

- Criteria and Trigger
  - Structure to assess
  - Compare to criteria
  - Trigger actions
- Gather and Share
  - Collect information
  - Structure information
  - Provide insight
  - Share for common understanding

General Information Systems



General Information Systems



CyberInfrastructure

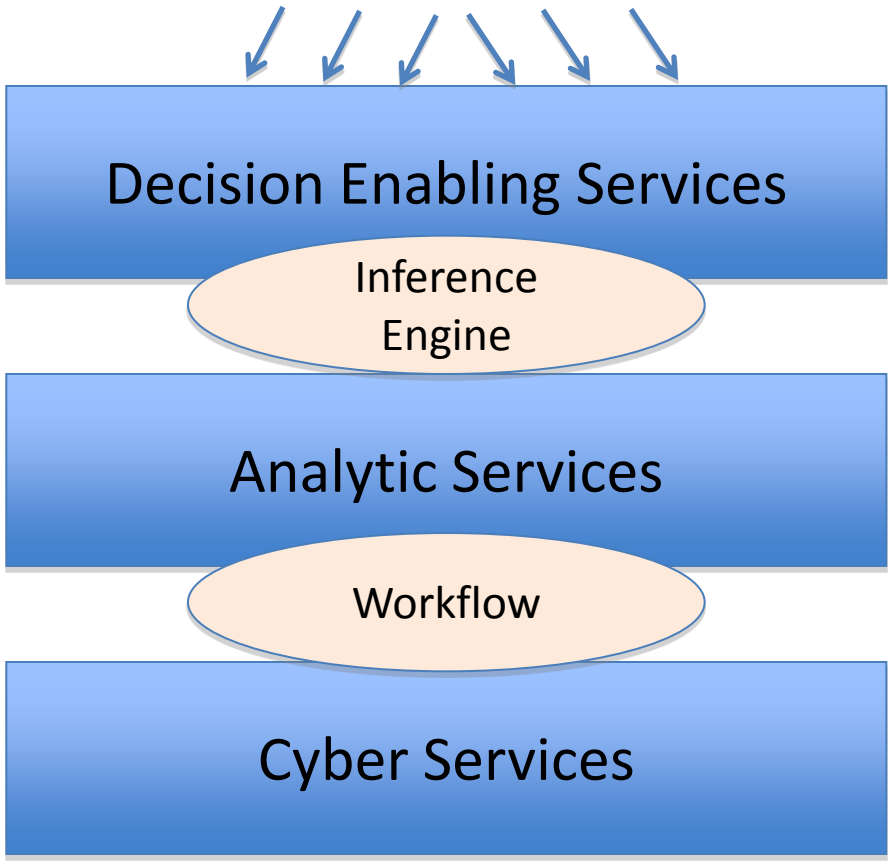
- Cyberinfrastructure describes the new research environments that support advanced data acquisition, data storage, data management, data integration, data mining, data visualization and other computing and information processing services over the Internet

- Cyberinfrastructure is a technological solution to the problem of efficiently connecting data, computers, and people with the goal of enabling derivation of novel scientific theories and knowledge.

WikiPedia, 2/15/11

Cyberinfrastructure Systems

Decision Makers



Knowledge Conveyance
Social Networks
Confidence and Uncertainly
Situational Understanding
Augmented Reality

AI/Rule Based inference
Analytics: geo, stat, mining, other
Complex Modeling
Collaboration (human conveyance)

Data Management and Federation
Distributed Computing and Mobile
Network Management
Workflow Management

Data Utility in Science Decision-Making

- Our value proposition is in the decisions based on science.
- Decision-makers really care about knowledge.
- “Consumers” are becoming more sophisticated.
- “Providers” need to provide value to consumer processes.
- Value is based on providing context, knowledge, and confidence.
- We need to develop “services” as part of cyberinfrastructure.
- Cyberinfrastructure enables keeping up with technology by focusing on enabling processes.

Questions

Ken Galluppi
(919) 445-9649
galluppi@renci.org

Renaissance Computing Institute
at UNC-Chapel Hill