

# Approaching the Network as a System

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# The (Distributed) System is Changing...

	Client-Server	3/N-Tier	Net Apps	Net Services	Soon	After that
Catch Phrase	The Network Is the computer	Objects	Legacy to the Web	The Computer Is the Network	Network of embedded things	Network of Things
System Collections						
Components						
Scale	100s	1000s	100,000s	1,000,000s	10,000,000s	1,000,000,000s
When/Peak	1984/1987	1990/1993	1996/1999	2001/2003	1998/2004	2004/2007
Leaf Protocol(s)	X	X	+HTTP (+JVM)	+XML, Portal	+RMI	Unknown
Directory(s)	NIS, NIS+	+ CDS	+ LDAP (*)	+UDDI	+ Jini	+ ?
Session	RPC, XDR	+CORBA	+CORBA, RMI	+ SOAP, XML	+ RMI/Jini	+ ?
Schematic						

# The Next Step Is Different

- The rules governing systems change
- Our problem set is different
- Reliability approaches change
- System evolve rather than get replaced

# The Rules Are Different

## New System Constraints

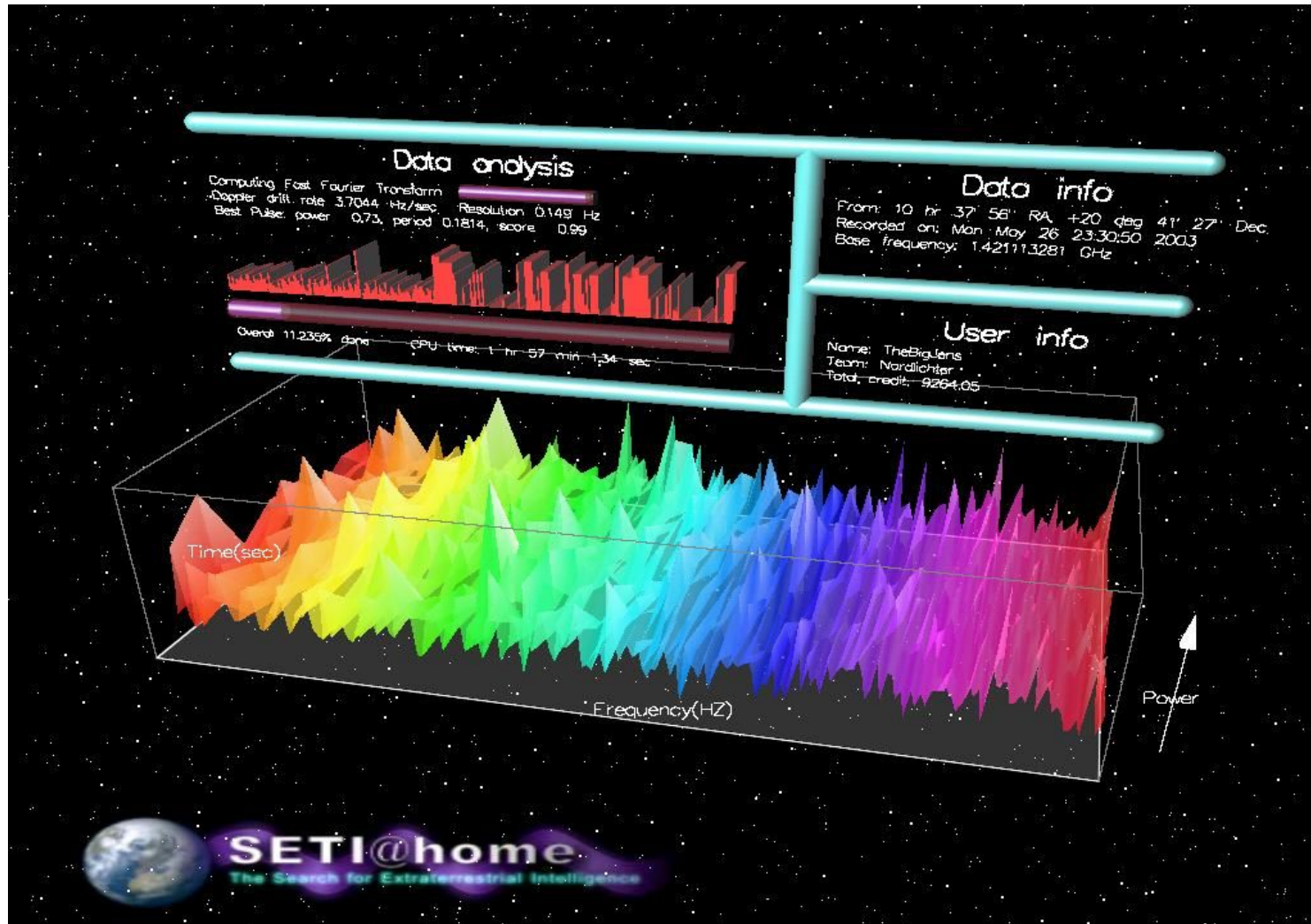
### Before

- Computation limits
- Storage limits
- Global system knowledge
- System is inside the box
- Component reliability
- Stable system

### Now

- Infinite computation
- Infinite storage
- Knowledge local, no consistent global state
- System is anything that can connect
- System reliability
- Evolving system

# Infinite Global Computation



# New Sets of Problems

- How to find the data
  - Infinite storage makes this hard
- How to pair computation and information
  - Once data is found, computing with it
- How to compute on partial data
  - No global quantification
  - Data changes faster than you can

# Reliability Is a System Property

- Individual machines will fail
  - With  $10^{10}$  machines, five 9s isn't enough
- The network system must remain
  - System must survive any component loss
- Components will be replaced
  - To repair faults
  - To introduce advanced components
  - To increase capacity

# System Evolution

- Network systems change over time
  - New components are introduced
  - New software is written
  - New functionality is required
- Changes must be made without
  - Interrupting current service
  - Shutting down the system

# We Have Some Previous Experience

- Flexible and adapting systems
  - Jini™ networking system
  - Jxta™ peer-to-peer system
  - LOCKSS for storage
- Sensor networks
- RFID infrastructure
- None of these have the scale...

# An Exploratory System

- Suppose you could
  - Place 6-12 monitors on
  - Each of  $10^8$  people
  - For 20 years...
- What kind of system would support
  - Primary care physicians
  - Public health
  - Medical research

# Some Preliminary Ideas

- Data delivery that is
  - Opportunistic (when on the net)
  - Reliable but maybe slow
- Filtering in the network
  - Allowing injection of code to clone
  - Pattern based matching
- Statistical computation
  - Over representative data

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