Symbolic Systems Technology Group

Using formal systems and logic to understand

- How things work
- Why things don't work
- ....

Team (alphabetical order)

- Grit Denker
  - Daniel Elenius
  - Rukman Senyake
  - Ashish Gehani
- Steven Eker
- Ian Mason
- Anupama Panikkar (SV)
- Andy Poggio
- Malabika Sarker (Oklahoma)
- Mark Oliver Stehr
  - Minyoung Kim

Projects (in no particular order)

- Maude Development
- Cyber-physical Systems (CPS)
- Circuit Analysis w Superresolved Infrared Optics (CASIO)
- Content Based Mobile Edge Networks (CBMEN)
- Biology

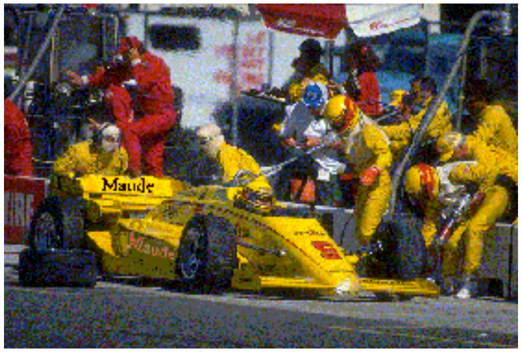
A smattering of each

Maude Development (Steven Eker)

w Meseguer@UIUC

Distributed/Concurrent Maude (NSF)

- many optimizations



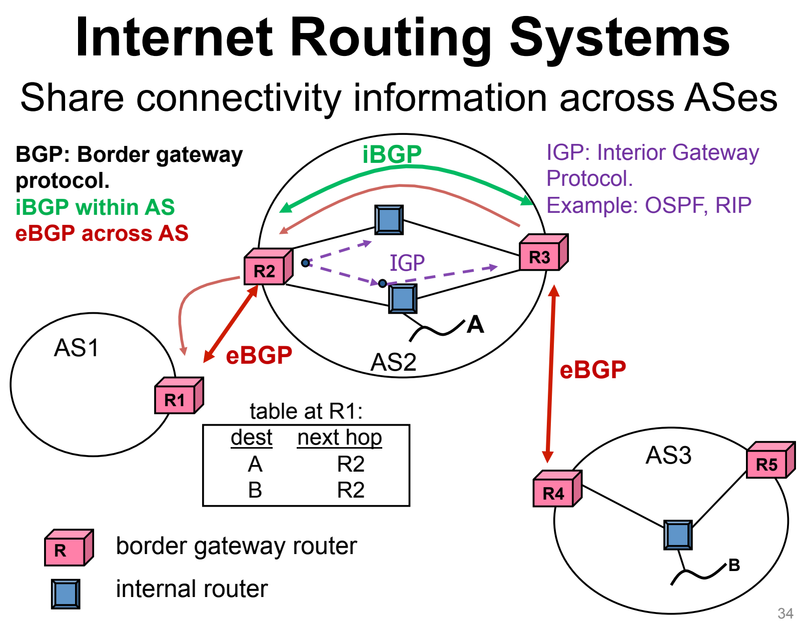
- new stack based execution engine
- concurrent search
- concurrent objects (eventually)

Unification (NSA)

- Unification is the problem of finding a substitution such that
  - t1 = u1 ... tn = un (in an equational theory)
- Free theory easy/finite
- Generally may be infinite, undecidable
- AC, ACU doable but challenging
- Key application narrowing
  - rewriting with unification rather than matching
  - backwards narrowing -- finds all initial states leading to target pattern
    - Maude NPA (crypto protocol attacks)
    - Document Logic (business process risks)

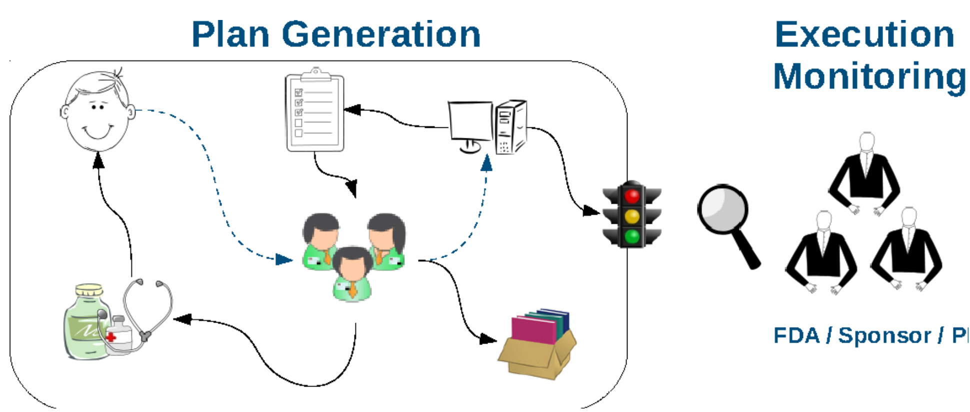
Some Maude Applications

- Border Gateway Protocol Analysis (Anduo Wang, Boon Tau Loo, Andre Scedrov UPenn)



- Modeling Regulations for Clinical Trials (Andre Scedrov (UPenn), Vivek Nigam (Munich), ...

  FDA regulations
  Requirements implicit in trial protocol
  Runtime monitoring
  Adaptive plan generation
  Post trial inspection



Cyber-physical Systems Projects

NCPS (NSF), Fractionated (ONR), CYPRESS (NSF)

(PDL,MOS, MK, IAM, AP, GD, ...)

http://ncps.csl.sri.com

Challenges and Objective

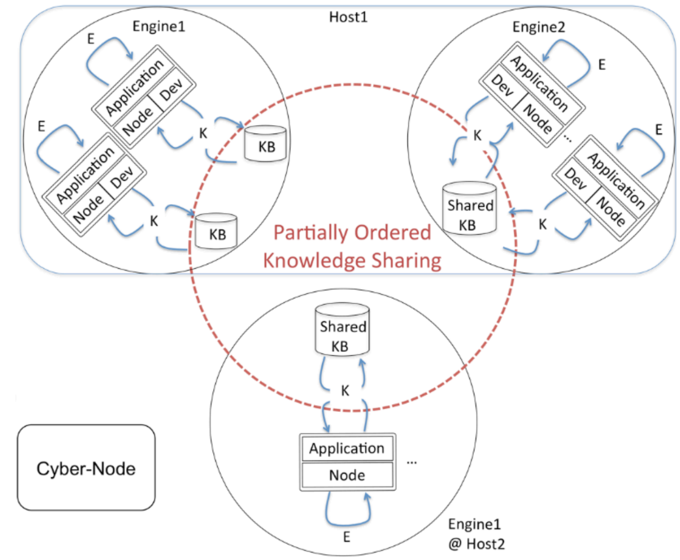
- Networked Cyber-Physical Systems (NCPS) consist of networked hard- and software components embedded in the physical world and interacting with it through sensors and actuators.
- Increasingly large numbers of *heterogeneous* and potentially *resource-constrained* and *unreliable* components
- Need to work in challenging environments with unreliable/intermittent connectivity
- Need to operate in the entire spectrum between autonomy and cooperation
- **Objective:** General principles and tools for building robust, effective NCPS using individual cyber-physical devices as building blocks.

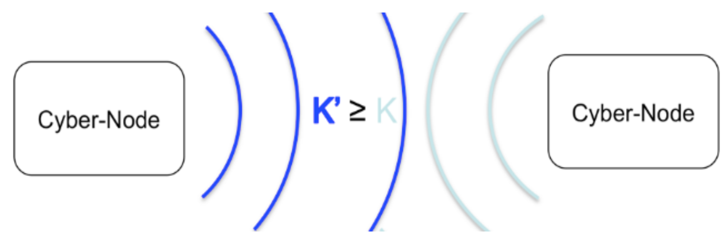
NCPS Approach and Contributions

- Partially ordered knowledge-sharing model for loosely coupled distributed computing
- Implemented in new application framework for NCPS
- Distributed logic for declarative control
- Simulation case study:
  - distributed surveillance, collaborating team of mobile robots

Partially ordered knowledge sharing

- Builds on DTN work,,minimal assumptions on network connectivity (can be very unreliable)
- Locally each cyber-node uses an event-based model with local time and may have attached cyber-physical devices
- Communication via knowlegde sharing rather than message passing
- Partial order allows the network to replace obsolete or subsumed knowledge
- Global consistency is not enforced (impossible in disruptive environments)
- Avoids strong non-implementable primitives, e.g. transactions

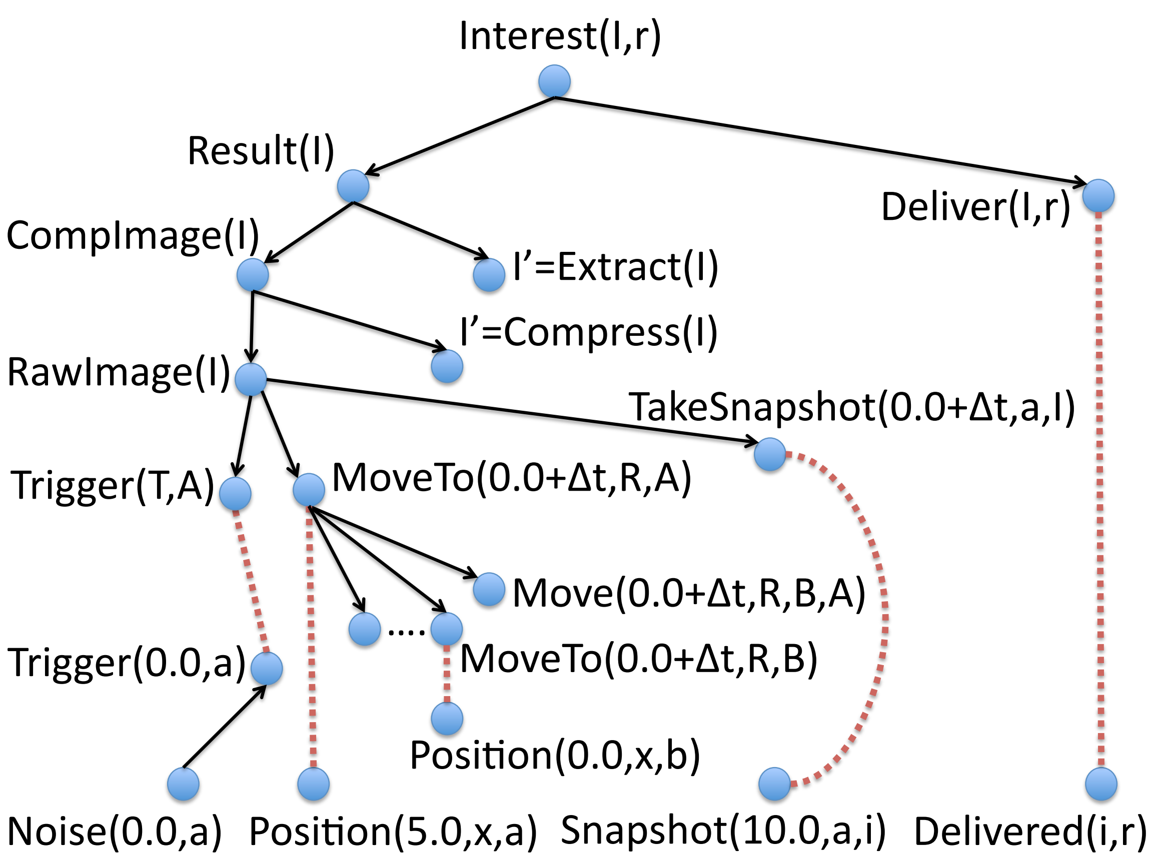


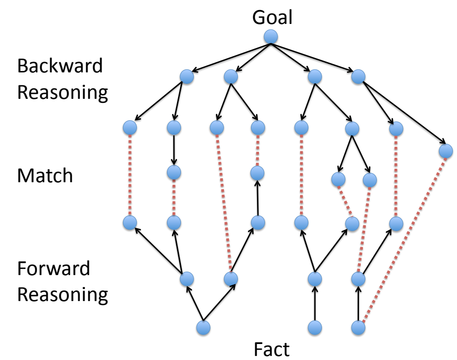


Distributed Logic

- **Key Problem**
  - Traditional logics are not designed for distributed reasoning
  - Logics are traditionally closed systems, i.e. not interactive
- **Knowledge is transparently shared**
  - Knowledge = Facts + Goals
  - Facts can represent observations
  - Goals can represent control objectives
- **Distributed logical framework**
  - Integrates forward and backward reasoning
  - Partial order is essential part of the distributed logic

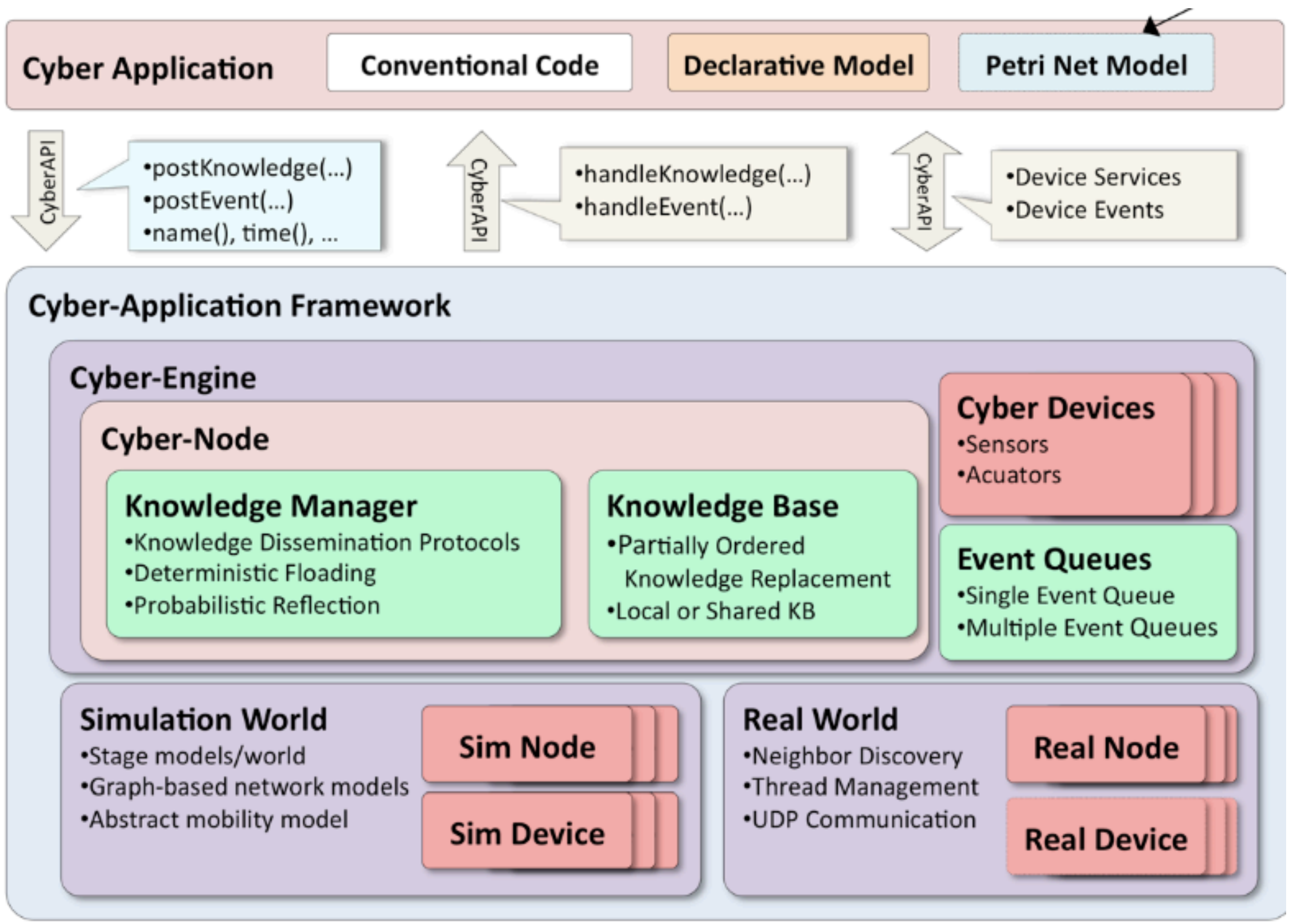
Distributed derivation





Cyber-Application Framework Architecture

- Cyber-framework implements partially ordered knowledge-sharing model
- Logical framework is implemented as a cyber-application
- Applications cannot distinguish between simulation and reality



Principles and Foundations for Fractionated NCPS

- **Problem:** Current models are too abstract by not taking into account fundamental physical limitations and hence are not efficiently implementable or scalable
- Once explicitly represented, physical limitations can be overcome to some degree (e.g. probabilistically)
- Diversification, redundancy, and randomization can offset many physical limitations
- Distribution is a source of redundancy and diversification and can be turned from an obstacle into an advantage

STEM: A Stochastic Task Execution Model for Fractionated Software

- Fractionated software system composed of nodes with partial connectivity (many, small components -- fracments).
- A goal is posted which is comprised of numerous subgoals
- Stochastically, a free node will take on a new subgoal (if capable)
- Correctness? Measure goal accomplishment quality,
    - e.g. at least 90% subgoal coverage at 95% confidence level

CYPRESS

Cyber-Physical RESilience and Sustainability

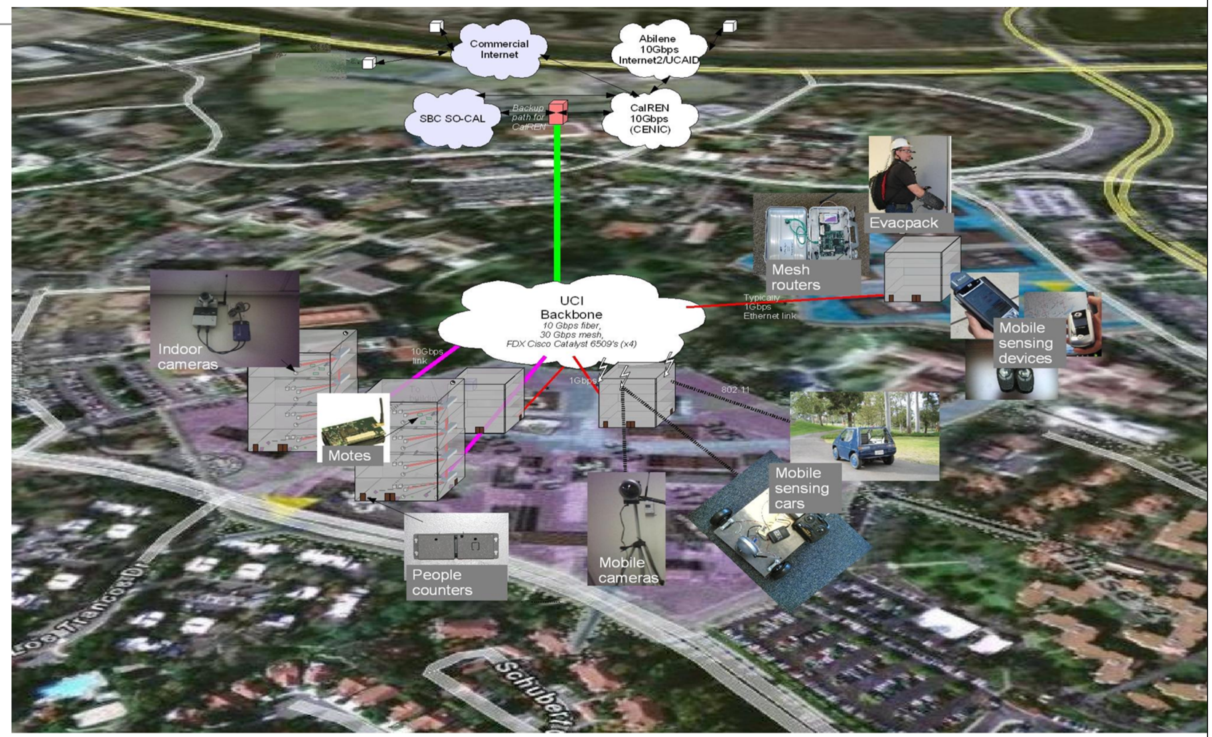
Dependability Techniques for Instrumented Cyber-Physical Spaces

Grit Denker, Nikil Dutt, Minyoung Kim, Sharad Mehrotra, Mark-Oliver Stehr, Carolyn Talcott, Nalini Venkatasubramanian
Leila Jalali, Zhijing Qin, Ronen Vaisenberg, Xiujuan Yi, Liyan Zhang

UCI & SRI

Goals & Approach

- Principles / techniques for infrastructure and data resilience
- Formal models and cross-layer tuning
- Middleware services
- Pervasive space testbed



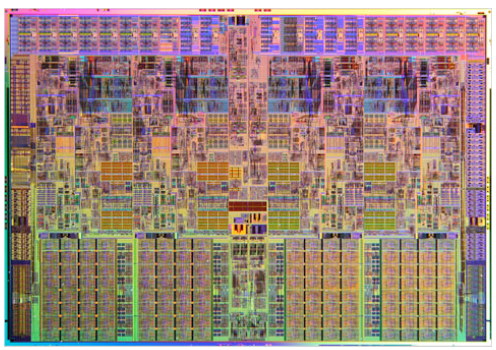
Instrumented UCI Campus

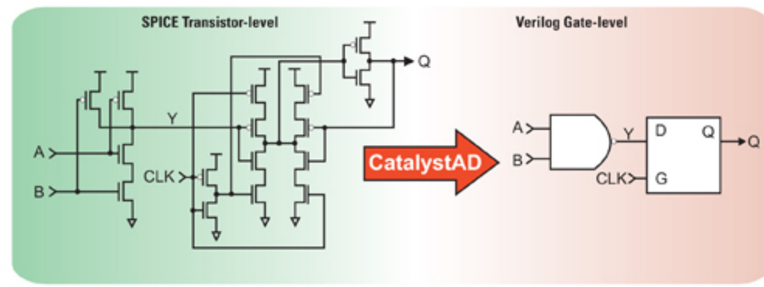
CASIO: Circuit Analysis w Superresolved Infrared Optics (DARPA)

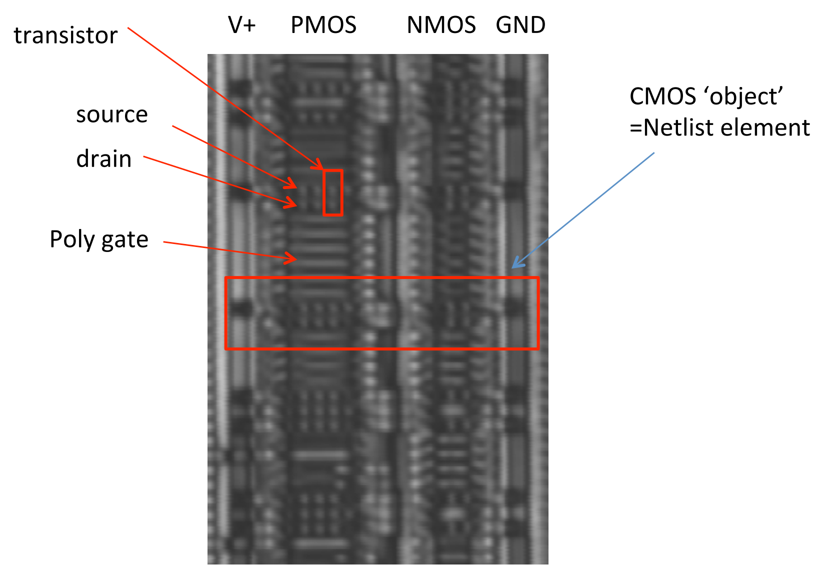
ESD,PSD,CSL,AI, Princeton, Berkeley, ...

The CASIO challenge (DARPA hard^2)

- Identify potential malicious regions in an ASIC
- Chip must work after analysis
- Aim for 45 nm resolution (currently 150ish)





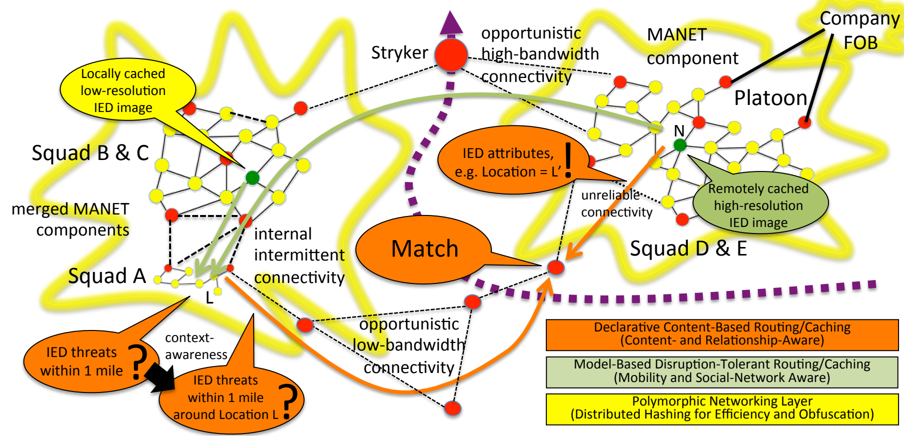


ENCODERS: Content Based Mobile Edge Network (DARPA) (MOS and many others, in negotiation)

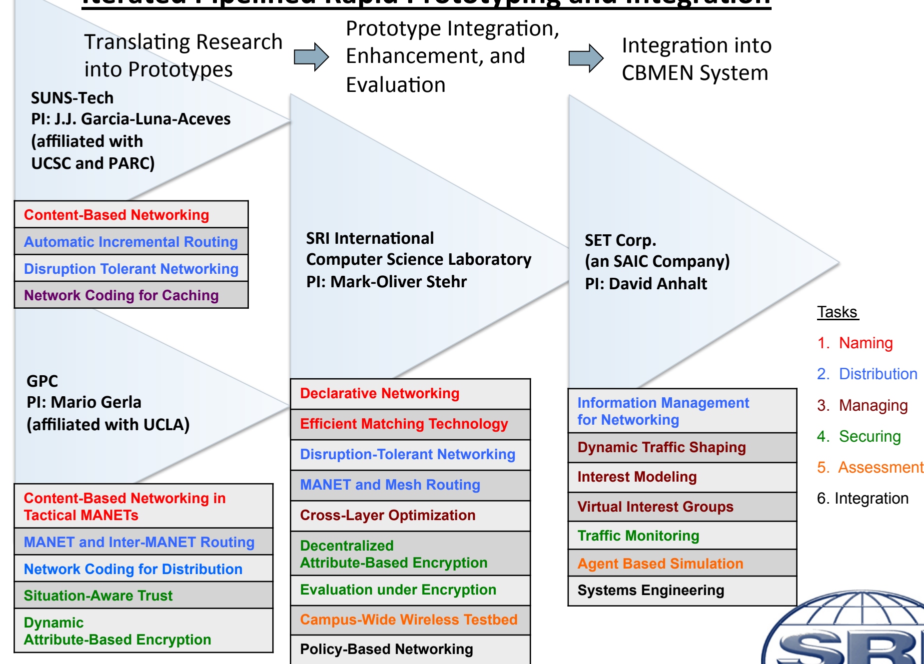
CBMEN ENCODERS
Edge Networking with Content-Oriented Declarative Enhanced Routing and Storage

- **Declarative/Intentional Content-Based Networking:**
  - Vision of network as a distributed cache of content: users/applications state what content is needed, without constraining how to obtain it !
  - Enable fine-grained expression of warfighters' needs: transition from syntactic (name matching) to semantic networking (predicate resolution)
  - Unified symmetric paradigm where requesters and originators of content express intent (i.e. query and scope)
  - Multidimensional awareness: users, groups, location, mobility, organization, social network, content/interest
- **Disruption-Tolerant and Attack-Resilient Foundation:**
  - Push and pull dissemination for increased robustness
  - Opportunistic caching and proactive replication
  - Polymorphic network layer (morphs like a Chameleon)
  - Spreading trust/responsibility through network coding
  - Decentralized multiauthority security for high availability
  - Fine-grained access control and metadata/query privacy
- **Impact: Focus on the Mission not on the Network !**
  - **Warfighter gets the right information at the right time**
  - Eliminate content flooding and information overload (for users and network) through fine-grained queries, efficient algorithms and context/interest modeling
  - Zero configuration: self-organizing combination of structured (distributed hashing) and unstructured (information diffusion) approaches

SUO Scenario: Content Sharing across MANET Clusters



Iterated Pipelined Rapid Prototyping and Integration



Biology

- Pathway Logic
- Combining Pathways and Cheminformatics
- BioMarkers

Pathway Logic (PL)

http:pl.csl.sri.com

Executable models of cellular processes (Maude + Petri Nets)

- Queryable formal knowledge base (DKB) of experimental findings
- Executable network of reaction rules (inferred from DKB)
- Model ~ initial state (experimental setup) + relevant rules
- Analysis using the PL Assistant (PLA)
  - Find subnets (proofs, executions)
  - Find pathways (proofs, executions)
  - In silico knocks
  - Comparing networks
  - Following connections

Datum query

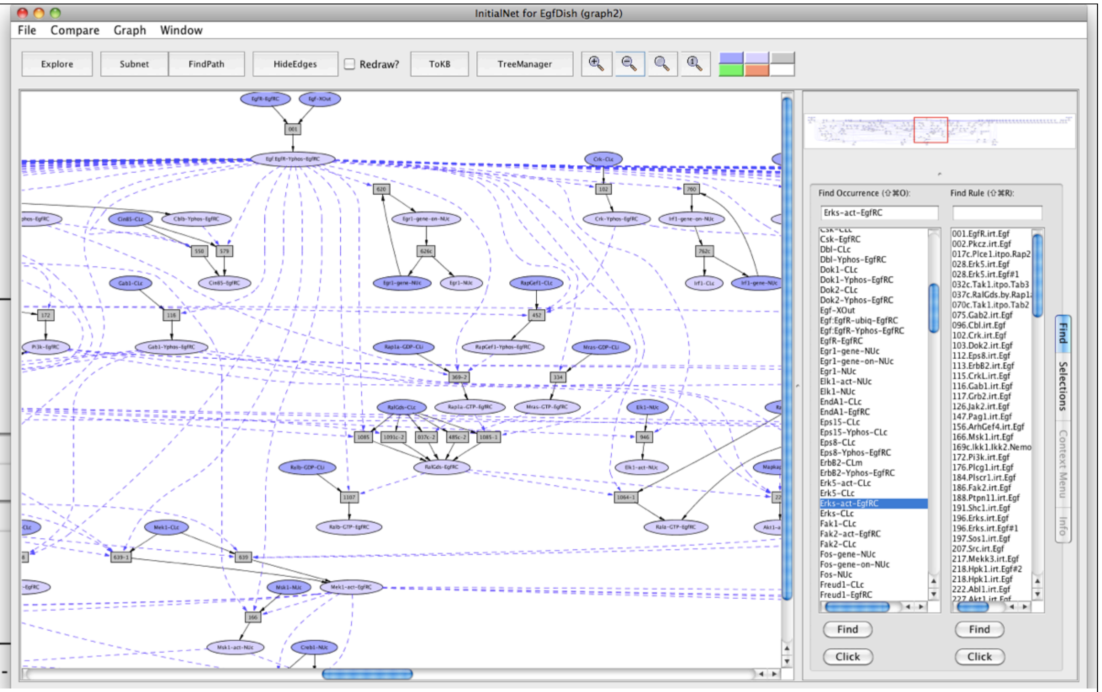
Signaling response to Egf (AMK)

Predicates

subject | entity | matches | Erk

assay | type | is a | ActivationAssay

Add a predicate Remove all predicates



50 of 407 Results

Export all results to txt or csv

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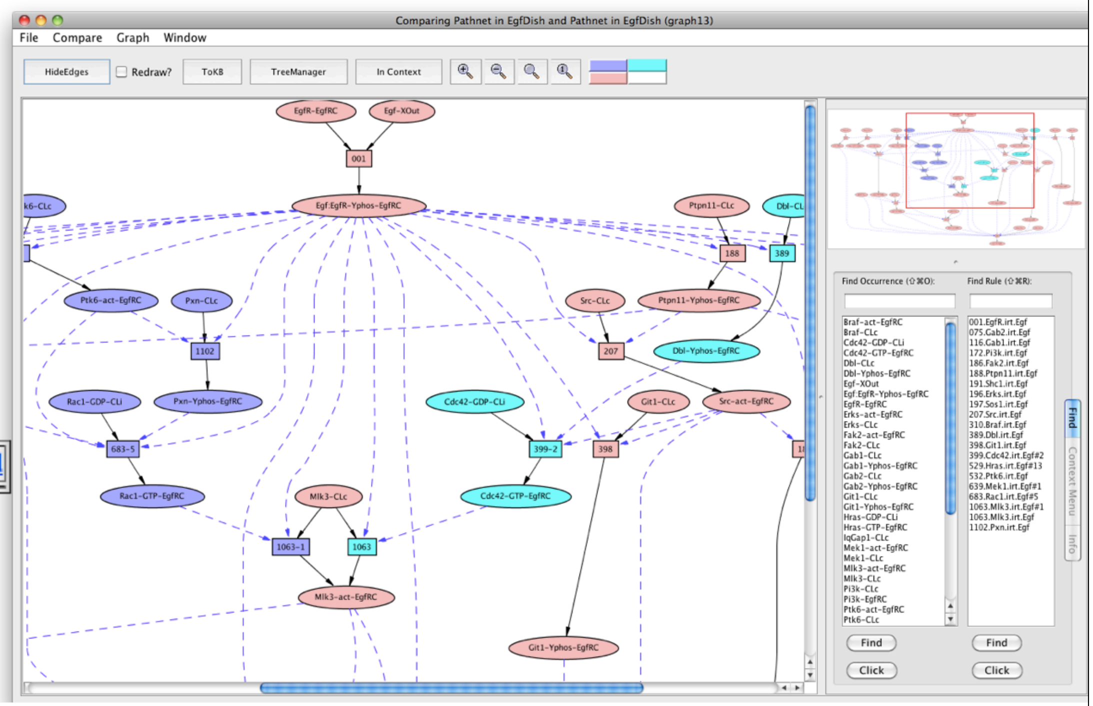
Expand All | Collapse All

Erks[Ab]IP IVKA(MBP)[32P-ATP] is increased irt Lps (times)	Expand

- cells: mPECs in BMS
- times: 0 7+ 15+ 30 60 90 min
- partially reqs: Irak1 [KO]
- source: 10754329-Fig-3c

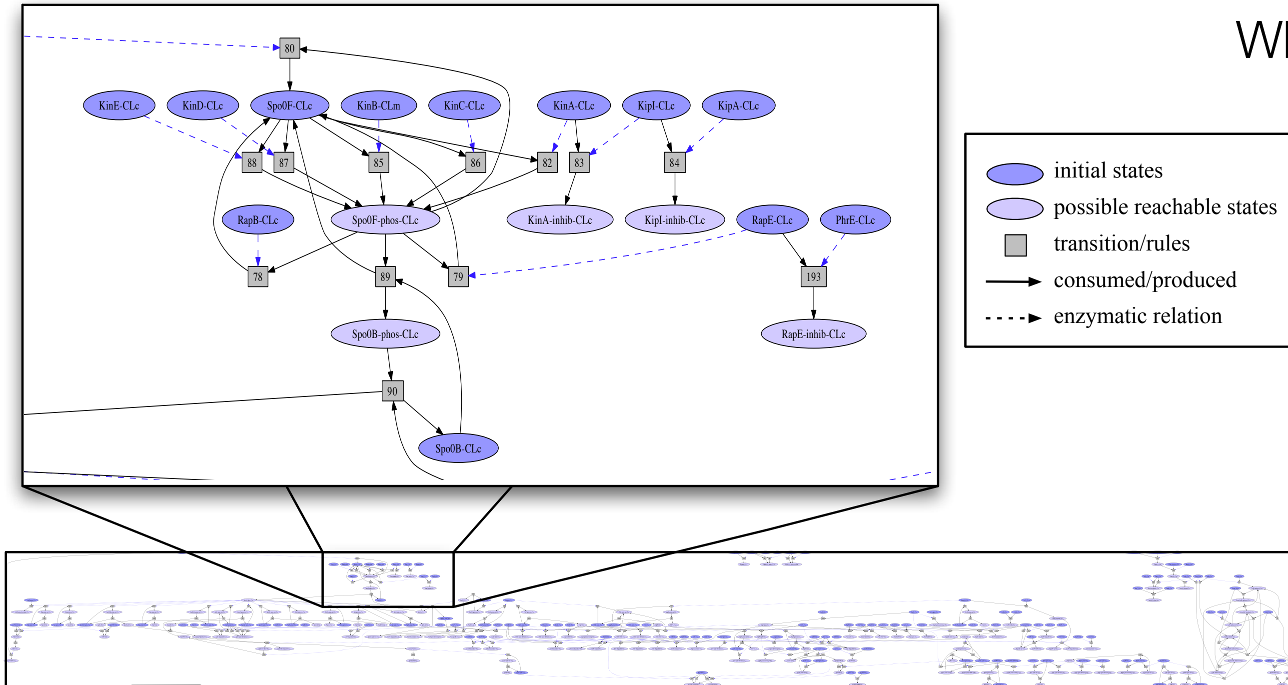
Erks[Ab]IP IVKA(Elk1)[32P-ATP] is increased irt Lps (30 min)	Expand



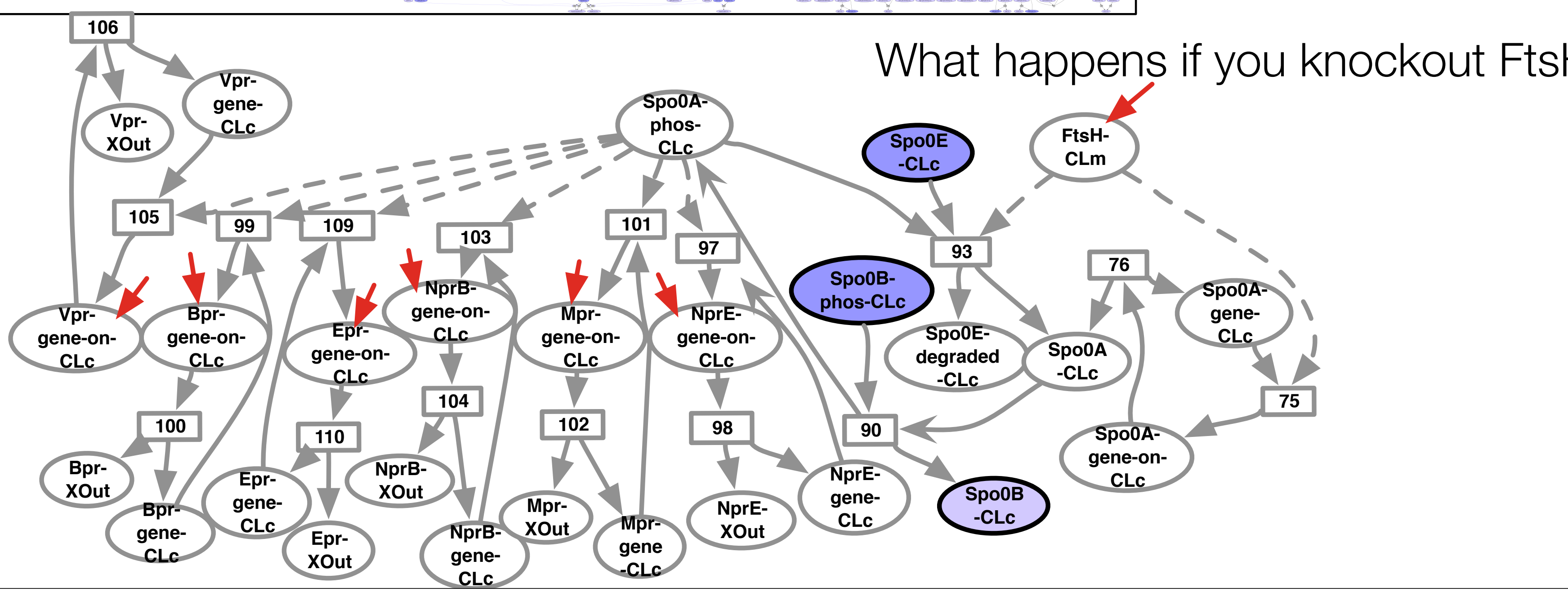
Two ways to activate Erk

Protease interaction network (Gram Positive Bacteria) (Anupama)

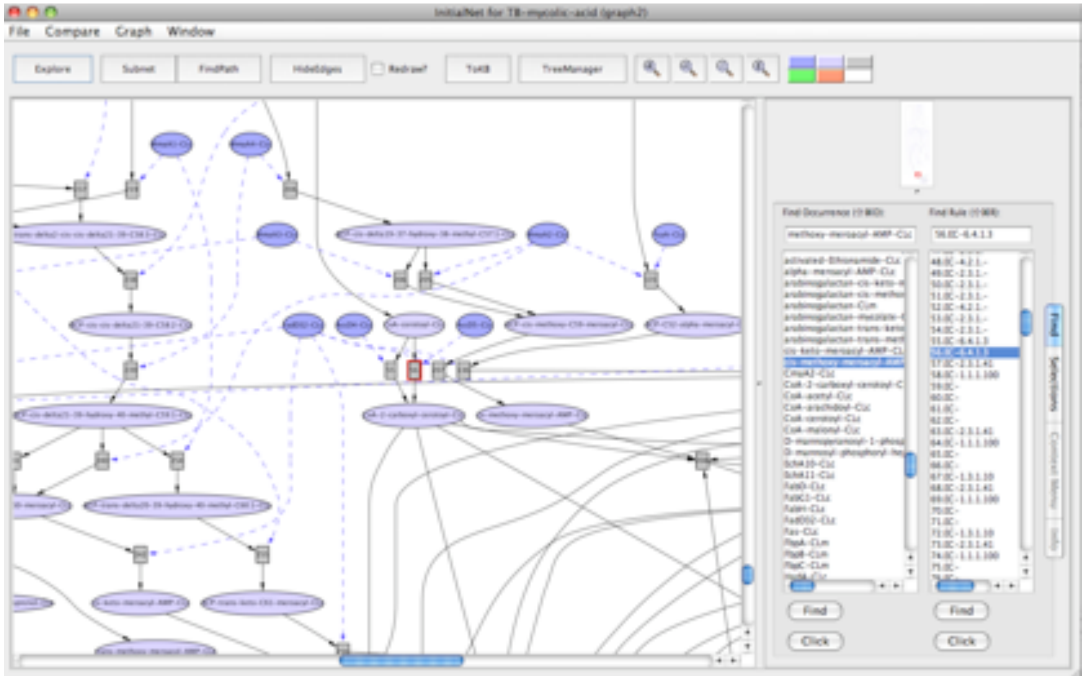
What regulates a protease, what does it regulate



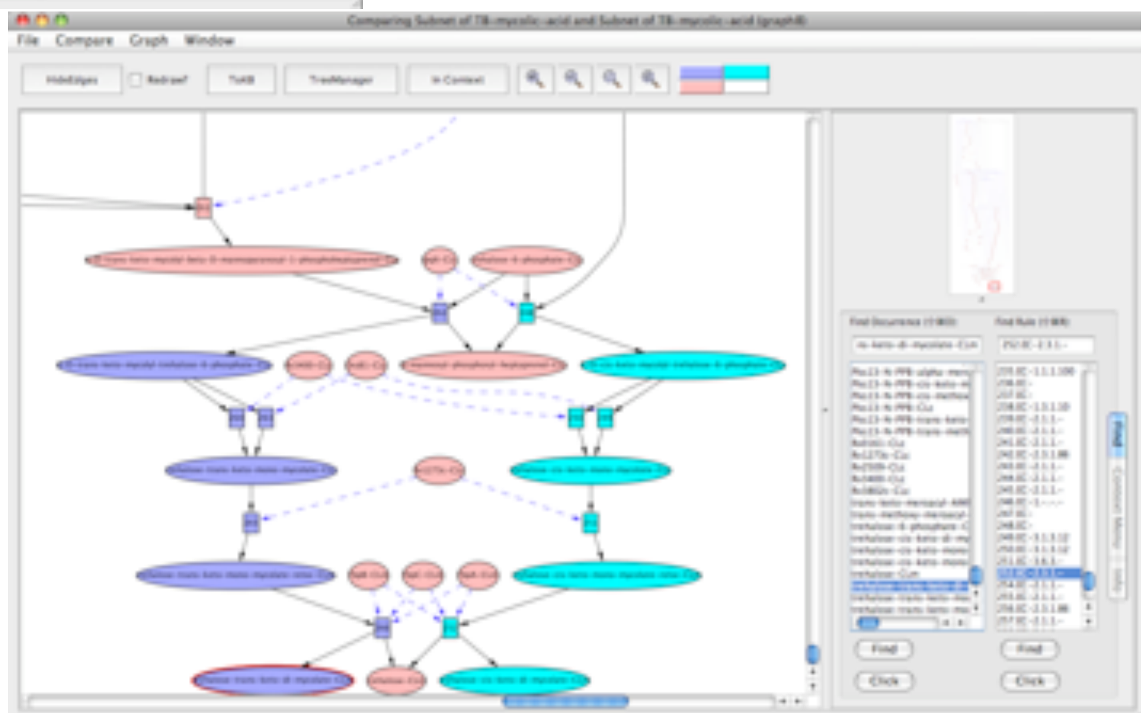
What happens if you knockout FtsH?



TB-mycolic-acid synthesis (Malabika)



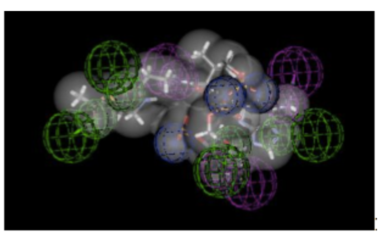
Multiple synthesis routes

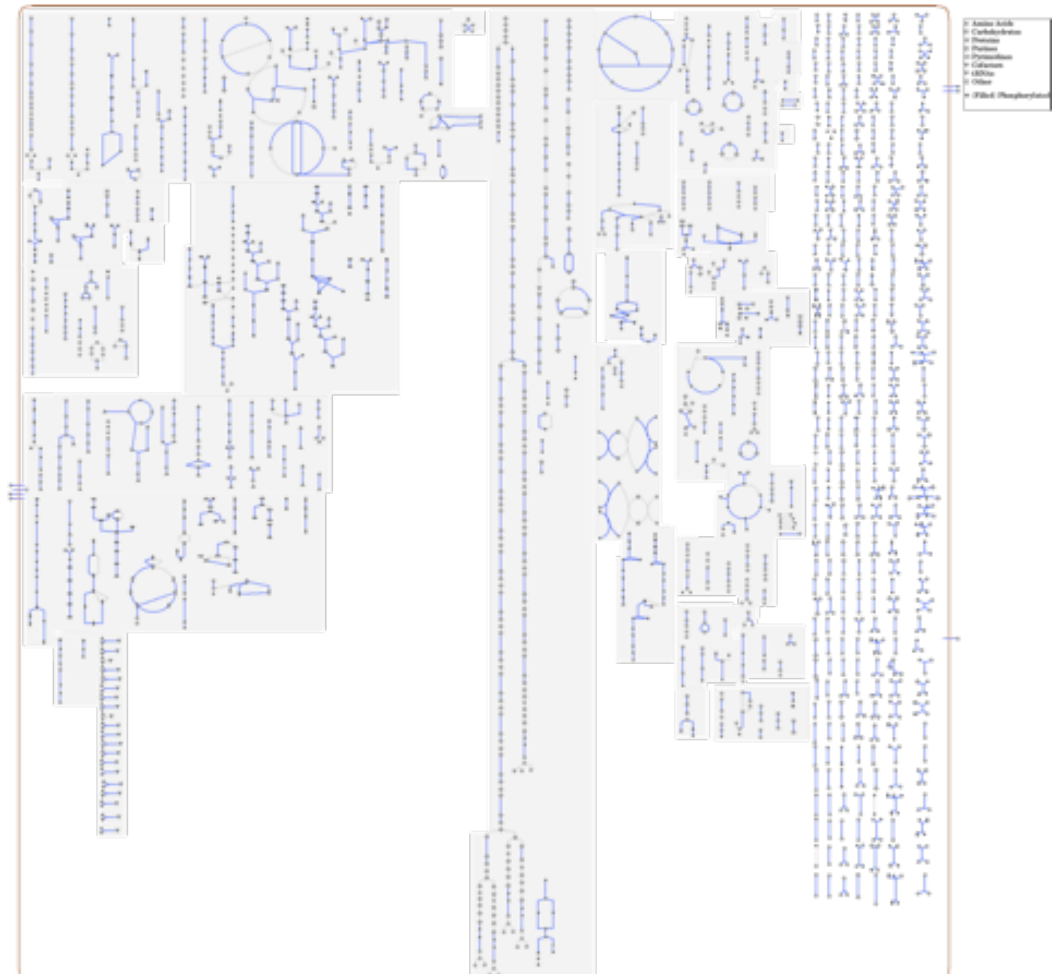


Combining Cheminformatics Methods and Pathway Analysis

NIH STTR with Collaborative Drug Design (CDD)

- Looking for TB drug candidates
- Phase I: Predicted 30 candidate drugs, tested 20, 3 had activity
- Phase II submitted.





Point-Of-Care Biological Assays for Determining Absorbed Ionizing Radiation Dose (Biodosimetry) (BARDA)

David Cooper PI -- PSD,BSD,ESD,CSL ....

- **Objective**: Biomarkers of irradiation for triage

- **Metric**: find panel of proteins that can distinguish >=6gy from <6gy in mouse

- Experiments:

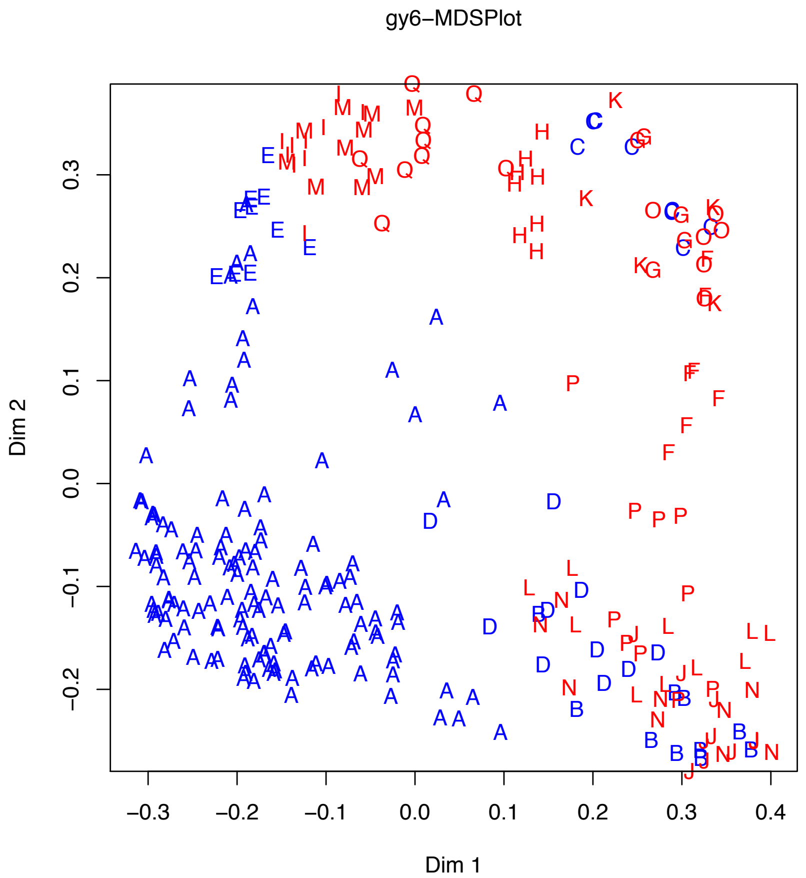
  - Mouse subjected to irradiation at different levels

  - Human (cancer patients undergoing radiotherapy)

- Data: Mass Spectra, Elisa of plasma samples

- Computational analysis:

  - Univariate statistics, multivariate linear classifiers, SVM



The end! (The beginning?)