Project Overview

• Developing algorithms, models, and analysis methods for highly dynamic distributed systems
  - Participants may join, leave, may change location.
  - Network topology may change.
  - Components may fail, recover.

• Complex systems, difficult to design, understand, analyze.

• Two approaches:
  - (1) Design, global communication and data-management services, efficient algorithms.
  - (2) Develop formal modeling and analysis techniques, based on interacting state machines (I/O automata).
(1) Services for dynamic distributed systems.

- Real-Time Dynamic Atomic Broadcast (RT-DAB) algorithm [Bar Joseph, Keidar, Lynch]
  - Consistent message sequences received by different participants
  - Message delay linear in the number of failures that actually occur.

- RAMBO: Reconfigurable Atomic Memory of Basic Objects [Lynch, Shvartsman]
  - Use read and write quorums to cope with transient failures
  - Reconfiguration protocol, based on Paxos consensus, to cope with long-term changes.

- Theoretical study of time for consensus in practical system models [Keidar, Rajsbaum]
  - Lower bound of $f+2$ rounds.

- Empirical study of methods of implementing synchronous models in the Internet. [Keidar, Bakr].

- Reliable multicast with caching [Livadas].

- Group communication services for WANs [Khazan].
2) Modeling and analysis

- IOA Toolset:
  - ioa2lsl translation to Larch theorem prover [Bogdanov]
- Theorem-prover case studies [Bogdanov, Luhrs]
- Simulator, including paired simulation [Dean, Ne Win]
- Connection from simulator to Daikon [Dean, Ne Win]
- Experiments in invariant discovery for IOA algorithms [Ne Win, Santos]
  [Kirli, Garland, Ernst, Lynch]
- Comprehensive paper on simulator.
- Near public release.

- Mathematics:

  - Dynamic I/O Automata (DIOA) [Attie, Lynch]
Research Plan for the Next Six Months

(1) Services for dynamic distributed systems

- Real-Time Dynamic Atomic Broadcast: Improve modularity, improve tolerance to variation in timing assumptions.
- RAMBO: Performance analysis, performance improvement, prototype implementations.
- Experimental study of other communication primitives over Internet.
- SRM, CESRM analysis
- GCS analysis

(2) Modeling and verification

- Improve IOA toolset for external users.
- New tools: Composer, connections with model-checkers, other provers.
- Experiments with Daikon invariant discovery; use in proofs.
- Case studies
- Use for agent languages (NePi2)
- DIOA, other extensions to basic I/O automaton model, language, tools