

Engineering Research Center for

Reconfigurable Manufacturing Systems



Fault Diagnosis Through Automatic Model Generation for Large-Scale Manufacturing Systems

Lindsay Allen

James Moyne, Associate Research Scientist

Dawn Tilbury, Professor



May 13, 2009

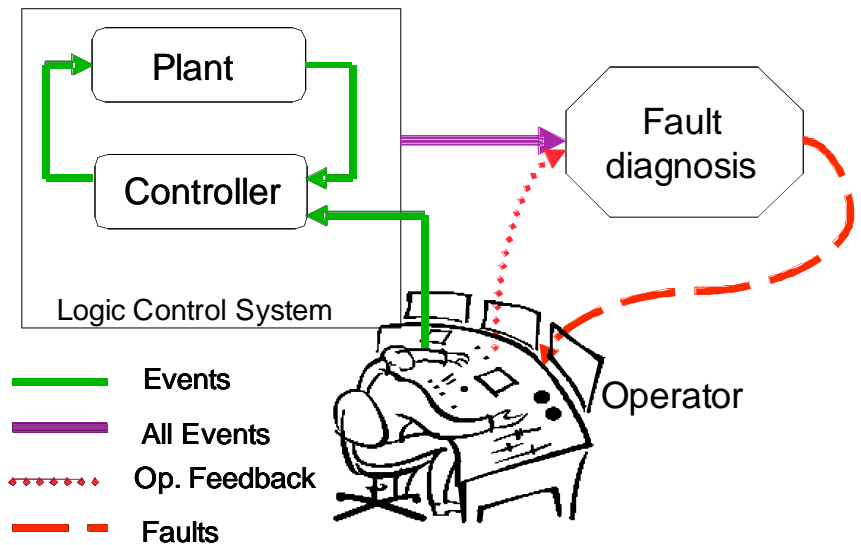


NSF Engineering Research Center for Reconfigurable Manufacturing Systems
University of Michigan College of Engineering

The University of Michigan, Ann Arbor

Fault Diagnosis Through Automatic Model Generation

- Goal: diagnosis of event-based faults in mfg systems without use of pre-existing formal model
- Approach: generate models based on training data; detect and diagnose based on certainty, performance of models
- Industry benefits
 - Reduced downtime
 - No interruption of normal operation for model learning
 - Modular approach reduces computational complexity

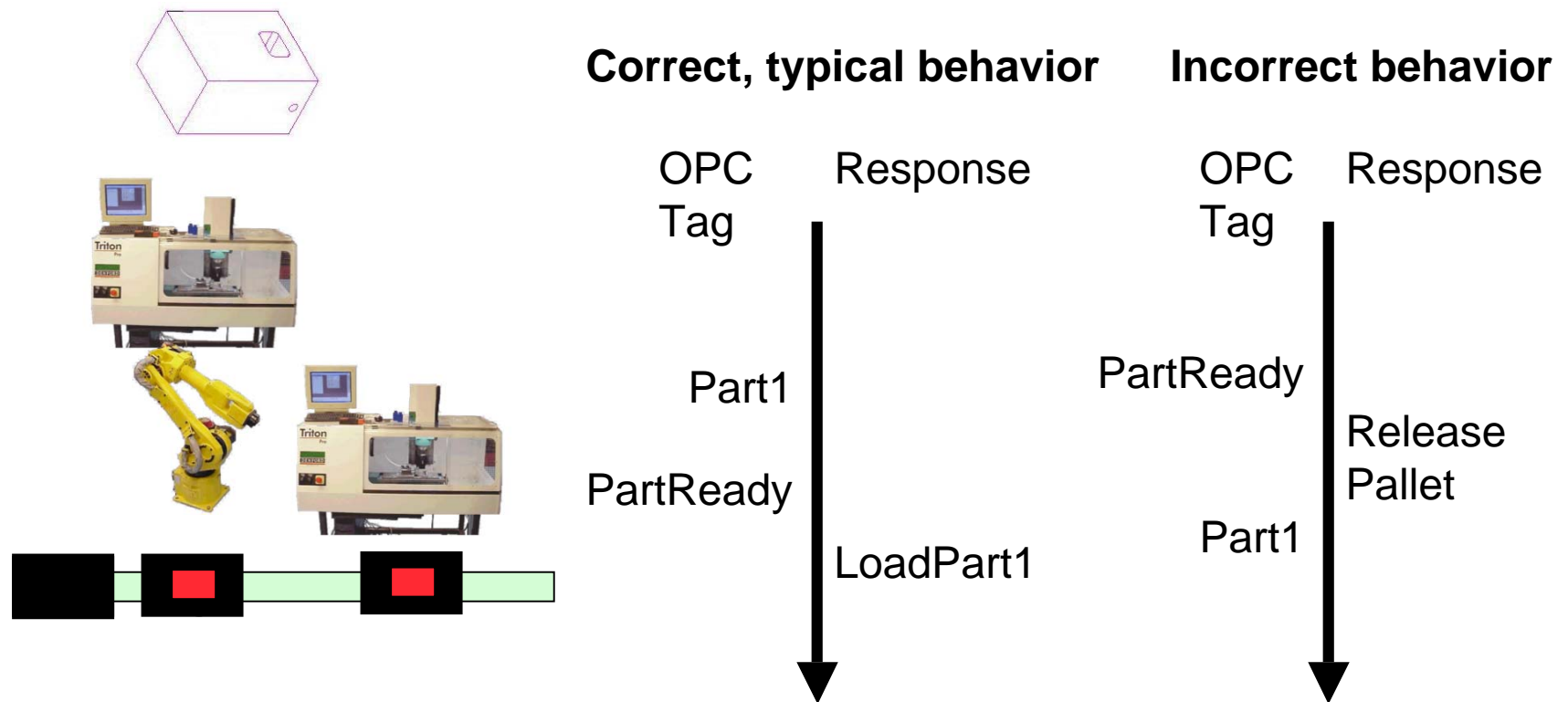


Outline

- Fault Diagnosis
 - RFT Example
 - Terminology
- Commercial Fault Diagnosis Software
- Solution Concept
- Deliverables and Benefits to Industry
- Milestones and Future Plans



Motivating RFT Example



- No model of entire system's correct behavior
- Manual inspection – laborious, offline
- Fault diagnosis using estimated model(s) – automated, online



Terminology

- Fault – deviation from correct behavior
- Detection – determining fault has occurred
- Diagnosis/classification – identify which fault occurred
- Within this work, “diagnosis” refers to detection and diagnosis



Commercial Fault Diagnosis

- Fault detection and classification (FDC)
 - SI Automation's Maestria, FabGuard FDC, Umetrics' Multi-variate analysis, Matlab's PLS toolbox for MVA
 - Multivariate analysis, stat. process control
 - Focus on tool-level rather than system-level
 - Detection in continuous rather than event data
 - **Gap: diagnosis system-level event data faults**

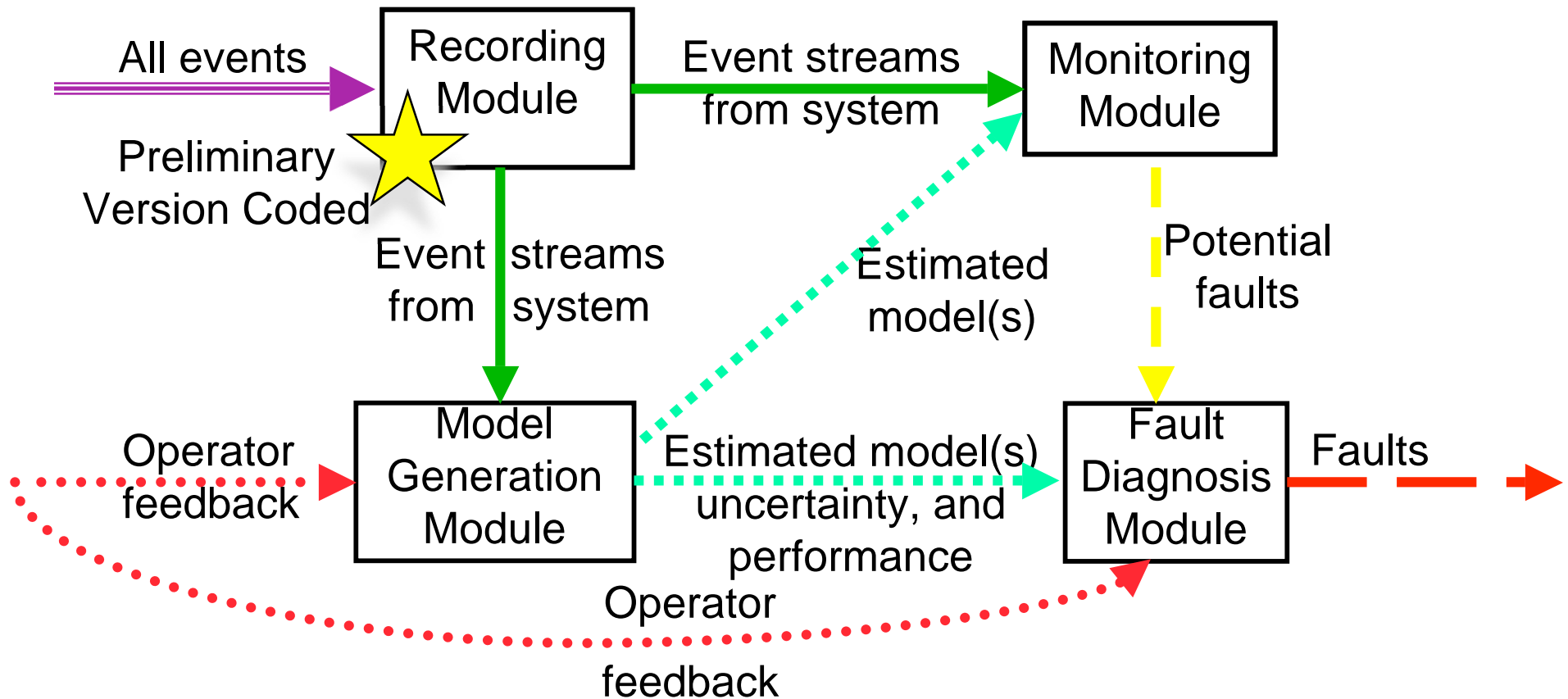


Solution Concept: Fault Diagnosis Using Model Generation

- Faults: evident in stream of the process' events
- Processes: modular sub-processes that interact through shared resources
- Input: streams of process' events, labeling of some events/streams
- Output: labeling of unlabeled events in the context of given streams
- Initially, do detection; eventually learn deviation to fault mapping to do diagnosis



Solution Concept: Modules



Leveraging Factory Health Monitor

- Goal: to integrate an event-based observer with a diagnostic scheme based on system identification to create a multilevel factory health monitor
- Provides preliminary version Recording Module

Factory Health Monitor

Display is paused

pause

The FHM has not been loaded.

Based on past performance 0.0 % of the time this sequence led to a unhealthy state
Based on past performance 0 % of the time this sequence led to a unhealthy state : Cell2 context filter.
Based on past performance 0.0 % of the time this sequence led to a unhealthy state : Cell1 context filter.

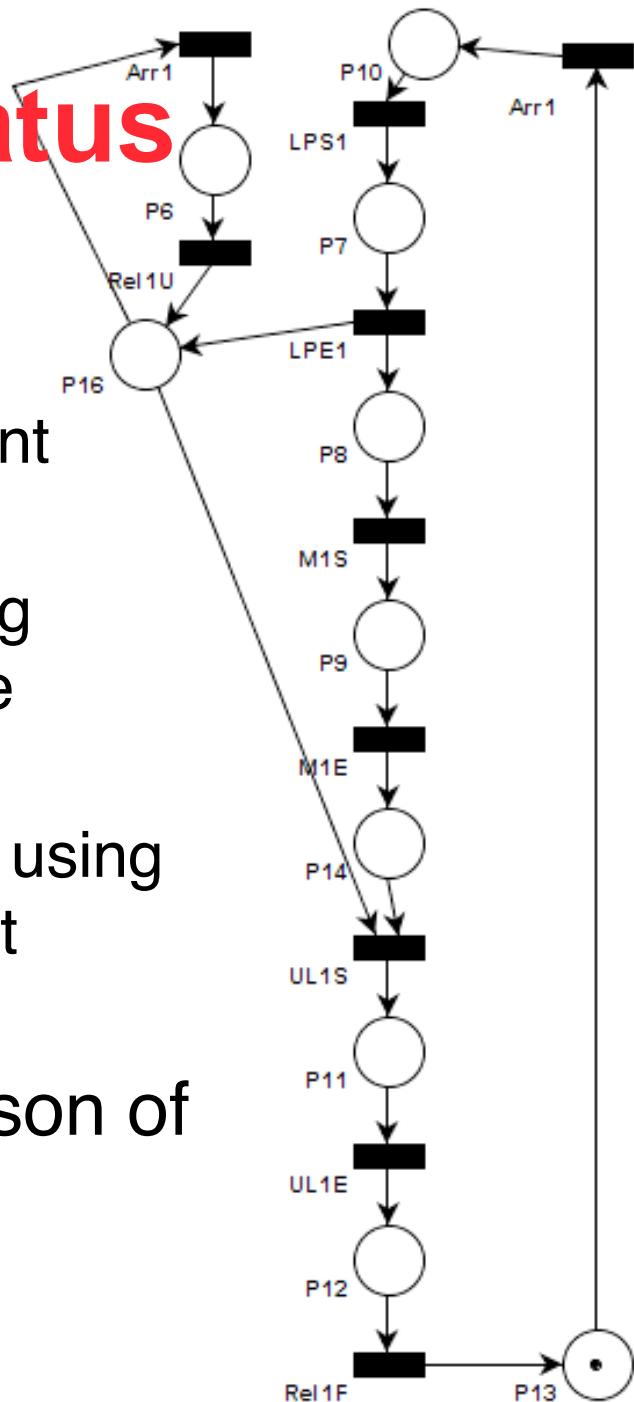
Rule Fired	Trigger	Response	Context	Firing Error
3	Cell1.Clamp1_OPC (0)	Cell1.Start1 (1)	all	true
4	Cell1.Clamp1_OPC (0)	Cell1.Start1 (1)	Cell1	false
5	Cell1.Start1 (1)	Cell1.Done1 (0)	all	false
6	Cell1.Start1 (1)	Cell1.Done1 (0)	Cell1	false
7	Cell1.Done1 (0)	Cell1.Clamp1_OPC (1)	all	false
8	Cell1.Done1 (0)	Cell1.Clamp1_OPC (1)	Cell1	false
9	Cell1.Clamp1_OPC (1)	Cell1.Robot_P1M1 (1)	all	false
10	Cell1.Clamp1_OPC (1)	Cell1.Robot_P1M1 (1)	Cell1	false
9	Cell1.Clamp1_OPC (1)	Cell1.Robot_P1M1 (1)	all	false
10	Cell1.Clamp1_OPC (1)	Cell1.Robot_P1M1 (1)	Cell1	false
11	Cell1.Robot_P1M1 (1)	Cell1.Robot_away_out (1)	all	false
12	Cell1.Robot_P1M1 (1)	Cell1.Robot_away_out (1)	Cell1	false

Load FHM Start Recorder Stop Recorder Reset



Current Status

- Preliminary algorithms
 - Model generation based on event streams
 - Training generated models using labeled event streams; calculate performance of each
 - Diagnosis of unlabeled streams using generated models and their past performance
- Missing: uncertainty, comparison of model generation techniques



Deliverables

- Methodology and algorithms
- Prototype software modules
 - Record OPC events
 - Model generation through system identification
 - Monitor current execution vs. expected by model(s)
 - Fault diagnosis based on estimated model(s)
- Application of methodology, software to RFT
- Industrial plant pilot study (?)



Benefits to Industry

- Event-based fault diagnosis is possible for manufacturing systems
 - That are lacking pre-existing formal model
 - Whose formal model may be incorrect or incomplete
 - That have formal models but ones that cannot be used dynamically for fault diagnosis
- Modular approach reduces computational work load and improves understanding
- Training and testing can be done without interfering with system operation



Milestones and Future Plans

