Model-driven Performance Analysis of Reconfigurable Conveyor Systems used in Material Handling Applications

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Presentation Roadmap

Motivation

- Conveyor systems
- Why Reconfigurable Conveyors?
- Challenges and Solution

Conveyor Systems











 Traditional Conveyor Systems (UPS, FedEx) Reconfigurable Conveyor Systems(DynaCon)

Why Reconfigurable Conveyors?

- Flexibility
- Scalability (Sustainability)
- Cost Effective



Basic Elements of Reconfigurable Conveyors

Segments



Turnarounds



Example of Reconfigurable Conveyors



Challenges

- Frequent changes in product lines
- With changes in layouts, how do we answer these questions?
 - Maximum sustainable rate?
 - Starvation of certain paths?
 - Inter material spacing?
 - Prioritization?
 - Fault tolerance?



Solution

- Model-driven Performance Analysis
 - Analysis engine
 - Domain-specific modeling language
 - Automation through generative capabilities



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Design of Framework

- Overview of Architecture
- Metamodel, DSML, and Generative Capabilities
- Analysis Engine: Cyber and Physical Models

Overview of Architecture

Design-time performance analysis framework GME based structural models MATLAB Simulink based behavior models



Code Generation

Meta-model and Domain-specific Model

Meta-model

Heart of the Domain-specific Modeling Language

Domain-specific Model

High level of abstraction of the system

- Configures attributes for the building blocks
- Allows analysts to create topologies
- Transforms into the underlying artifacts

Generative Capabilities



Analysis Engine

Cyber Models

Logical controllers implemented by Simulink Stateflow

Physical Models

Physical behaviors implemented by Simulink blocks

Conveyor Skids

- Modularized units
- Self-contained unit representing both cyber and physical elements

Analysis Engine : Cyber Models



Segment Transfer FSM





Turnaround Receiver FSM

Analysis Engine : Cyber Models



Turnaround Transfer FSM





Segment Receiver FSM

Analysis Engine : Physical Models

Physical models in the analysis engine Abstract view of Segment



Analysis Engine : Physical Models

Physical models in the analysis engine Abstract view of Turnaround



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Experimental Results

Experimental Results

Example reconfigurable conveyor system



Package Type	Length of Package		
Small Package	lm		
Medium Package	1.5m		
Large Package	2m		

EXPERIMENT PARAMETERS

Block Type	Belt Velocity	Belt Length	Sensor Zone	RX WD	TX WD	COMM WD
Segment	1 m/s	20 m	2 m	10 secs	10 secs	0.5 secs
Turnaround	1 m/s	5 m	1 m	10 secs	10 secs	0.5 secs

Experimental Results

Experiment 1



Experimental Results

Experiment 2

NUMBER OF PACKAGES ARRIVED FOR DIFFERENT COMM_WD TIMER VALUES

COMM_WD	Small Packages Arrived	Medium Packages Arrived	Large Packages Arrived
0.5sec	94	94	78
0.1sec	102	79	62



Comparing the Total Numbers of Packages Arrived

Concluding Remarks and Future work

- Model-driven analysis framework for reconfigurable conveyor systems
 - Decouples structural models from behavior models
 - Evaluates the properties of the topology proposed
 - Automation through generative capabilities

Future work

- Fault-tolerant reconfigurable conveyor systems
- Prioritizing packages according to types
- General framework of reconfigurable conveyor systems through commonality and variability analysis

Question?