Scheduling of Graph-based End-to-End Tasks for Distributed Multi-criticality Systems

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Motivation

- Fault handling in the self-healing system

The Self-Healing System for The Power Grid in China

- Decision Layer: Assessment, Fault Handling, Restructure, Emergency Plans, Black-Start
- Analysis Layer: Network Modeling and Analysis, Online Risk Diagnosis, Safety Pre-Warning
- Support Layer: Data Fusion, CooperativeRule Engine, Real-Time Multi-Agent Interaction

Key Facilities
- Distributed Intelligent Self-Healing Control System
- Interactive Intelligent Protection Control Device
- Self-Healing Protection Control Device
- Preventive Protection Device for Distribution Network
- The Existing Distribution Network Related Facilities

Unified Support Platform for Intelligent Power Distribution Unit

Communication Network

The Master Station

Other Systems

Information Interaction
Motivation

- The fault-handling elements
  - The fault tree
  - The security operation graph
  - The mappings of the fault nodes to their operation graphs

- The fault-handling goal
  - Real-time execution of security operations with minimum fault spreading degree
Task Modeling for Fault-Handling

\[ \tau_i = \{ \tau_{i,j} \mid 1 \leq j \leq n_i \} \]

\[ \tau_{i,j} = \{ \tau_{i,j,k} \mid 1 \leq k \leq n_{i,j} \} \]

\[ \Psi = \{ \Psi(h), 1 \leq h \leq m \} \]

Node in Fault Tree  Security Action Node  Agent

Precedence between Sub-tasks of Safety Operation Graphs

Precedence between Sub-tasks of Safety Operation Graphs

Mapping from Sub-tasks of Safety Operation Graphs to Multi-Agent
The MCE2E Task Model

- The multi-criticality graph-based end-to-end task model
  - The inter-criticality-mode trees
    - Nodes in the tree ↔ criticality modes
    - Recovery and isolation mechanisms for mode changes
  - The intra-criticality-mode graphs
    - Each node defined by a parallel DAG
    - Subtasks in the DAG are pre-allocated to processors
  - Comparison
    - Variable $C_i$ and $D_i$ → end-to-end tasks
    - Distributed intra-criticality-mode structure with end-to-end deadlines → mixed-criticality tasks
MCE2E Task Examples
MCE2E Scheduling

- Complexity
- The initial criticality modes
  - Local-deadline assignment solution
- Criticality mode changes
  - Recovery
  - Isolation
MCE2E Criticality Mode Changes

- Recovery
  - Degraded execution of best-effort nodes

- Cluster grouping
  - One or minimal amount of critical nodes
  - A subset of best-effort nodes

- Isolation
  - Time partitions within the cluster
    - The critical nodes successfully scheduled
    - The least mode changes for best-effort nodes
Thank you