Center for Embedded Systems
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Synchronizing Finite State Machine Controllers for Distribution Systems

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Project Overview and Description

- **Project Description**

Distribution system: Suppliers (or “generators”)
Consumers (or “loads”)
Network of Switches.
generators and switches controlled by FSM

- **Problem**

Response to Failure and/or Reconfiguration Triggering Events

  - Synchronize individual FSMs
  - decentralized/distributed scheme
  - consensus

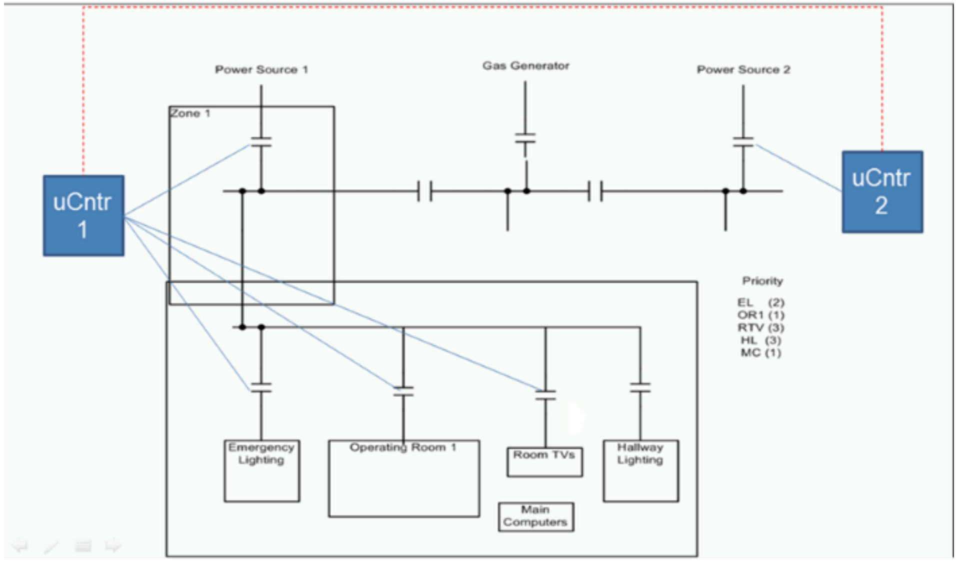
Approach

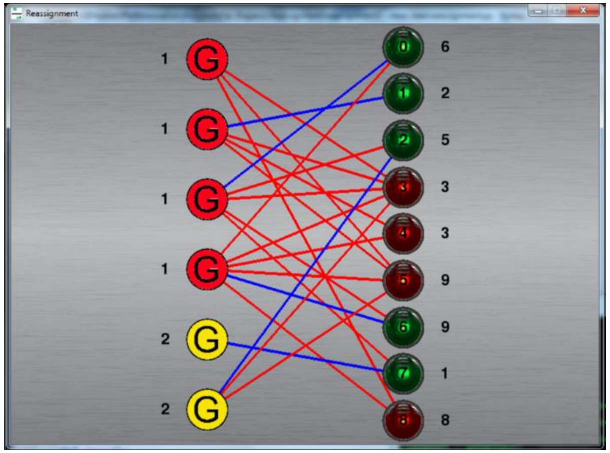
PREVIOUS:

1) **Developed in OMNET a decentralized algorithm so that all controllers learn the current topology of the network.**
2) **Developed Bipartite Matching Formulation to associate Generators to Loads.**

PROPOSED:

1) **Formulate Integer Linear Program (ILP) to associate Generators to Loads with Conflicts and Priorities.**
2) **Develop Heuristic and compare with the ideal (ILP)**
3) **Given a relay distribution network, find all conflicting assignments.**
4) **Timing considerations for Hand-over after Generator failure.**





Novelty

- **Novelty**

Existing work:

Fault-tolerance in Distributed Asynchronous Systems
Mathematical theory on decentralized control
& coordination of Discrete-Event Systems (DES)

No experimental verification has been given in the literature for specific systems. The proposed work will develop a practical methodology for a real-world industrial problem, namely the control/reconfiguration of the power supply system of an aircraft. The synchronization, consensus, and reconfiguration procedures will be simulated in OPNET.

- **Potential member company benefits**

○ **General model of a distribution system**
("suppliers," "consumers," "network of switches") :

○ **General reconfiguration events ("failure," "load balancing")**
it can be useful in many situations.

Project Tasks/ Deliverables

	Description	Date	Status
1	ILP formulation	Q1	Ongoing
2	Development of Heuristic and comparison with the ideal solution in terms of time and quality of solution.	Q2	Not yet started
3	Relay Configuration Algorithm for conflicting paths in relay distribution network	Q3	Not yet started
4	Timing Considerations and Scheduling for Hand-overs during Reconfiguration	Q4	Not yet started

Deliverables:

- **Comprehensive report on the DS modeling and synchronization, consensus, and reconfiguration procedures for the avionics power supply system.**
- **Software prototype tool (OPNET) and algorithms.**

Load Priority Mapping

- **Original Priorities (arbitrary values but sorted)**
  - **P1, P2, P3, P4, P5**
    - **P1: Highest**
  - **a_i : # of loads with priority Pi**
- **Assign new Priorities: Q1, Q2, Q3, Q4, Q5**
- **P5 => Q5 = 1**
- **P4 => Q4 = a_5 + 1**
- **P3 => Q3 = (a_5+1) * (a_4+1)**
- **P2 => Q2 = (a_5+1) * (a_4+1) * (a_3+1)**
- **P1 => Q1 = (a_5+1) * (a_4+1) * (a_3+1)* (a_2+1)**

Integer Linear Program

Maximize $\sum_{i=1}^{n} L_i * P_i$

subject to :

for each load *i*:

Σ_j **(incoming edge$_j$) <= L_i**

for each source *k* :

Σ_j **(outgoing edge$_j$) <= source_capacity C_k**

for each conflicting pair (edge$_i$, edge$_j$) :

edge$_i$ + edge$_j$ <= 1

Integer Variables:

0 <= edge$_j$ <= 1 (for all edges *j*)

0 <= L_i <= 1 (for all loads *i*)

Executive Summary

In the proposed approach, we plan to develop algorithms so that

- **(i) Strict Priority is enforced: all loads with the highest priority are supported as much as possible, i.e., no load with a higher priority is ever excluded even if many more loads of lower priority could be supported.**
- **(ii) Consensus on which relays to turn on/off is automatically reached by the matching formulation and the pre-computation of the conflicting pairs.**
- **(iii) the reconfiguration of the switches is done in the appropriate order so that no transient forbidden states are ever created.**