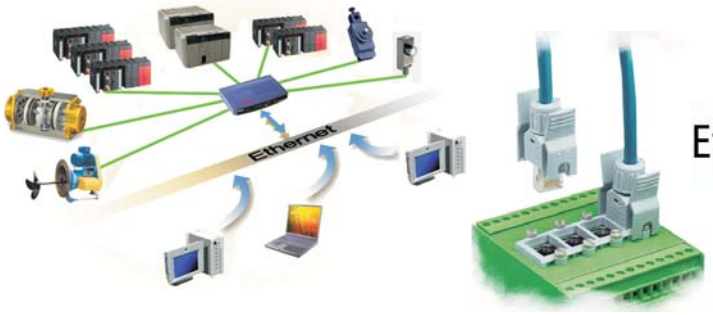
Operating Systems and Distributed Systems
University of Siegen
Department of Electrical Engineering and Computer Science

A Top-Down Approach for Realtime Industrial-Ethernet Networks using Edge-Coloring of Conflict-Multigraphs



- Non-deterministic CSMA/CD vs. TDMA
- Ethernet-standard vs. speed
- Merge needs of Automation Technology with trend towards Ethernet
- Develop a new approach, independent from existing hardware ("Laptop connected as well")

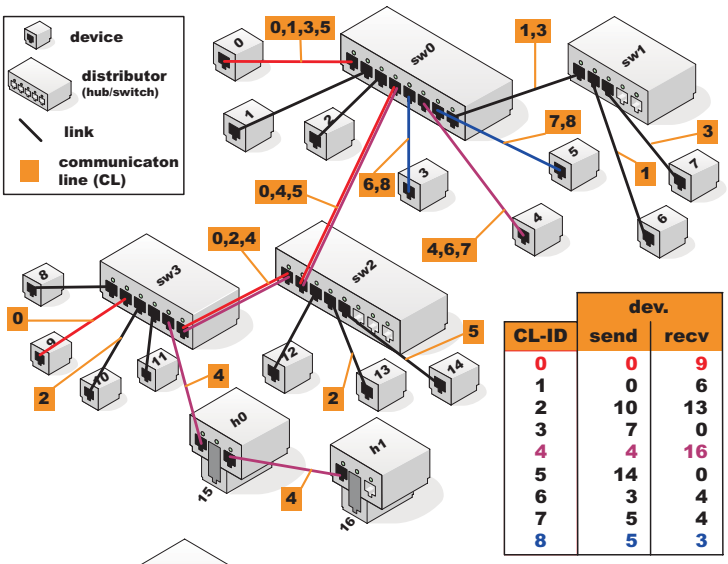
PROFINET INDUSTRIAL ETHERNET

ETHERNET POWERLINK

Network infrastructure
- Tree topology
- Line topology emulated
- Switches and/or hubs
- Delay & jitter ignored
- Half-duplex connections

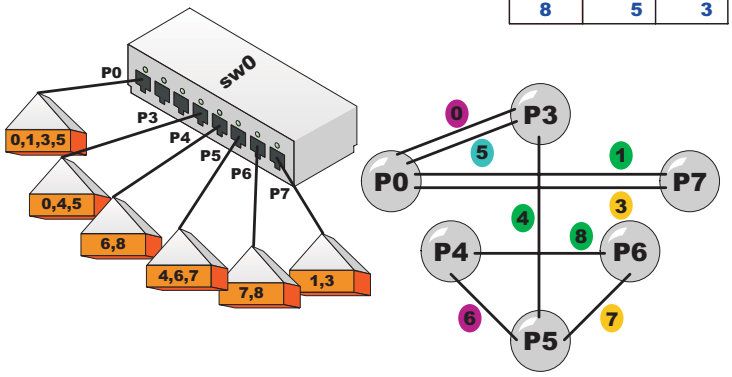
Device requirements
- Sending & recieving device
- Unicast & broadcast
- Sending at each prod. cycle
- Uniform length (MTU)
- No causal dependencies

Generate communication-lines (CL)
- Choose a root switch arbitrarily
- Find path from device to the root
- Concatenate 2 paths to 1 communication line

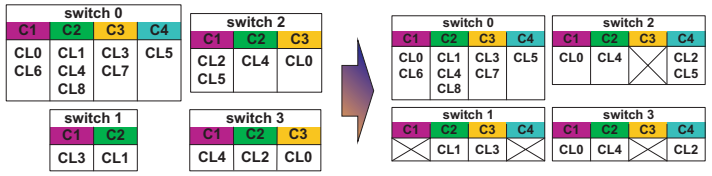


CL-ID	dev. send	dev. recv
0	0	9
1	0	6
2	10	13
3	7	0
4	4	16
5	14	0
6	3	4
7	5	4
8	5	3

Build conflict-multigraph; Greedy edge-coloring heuristics
- Each switch can be treated independently in half-duplex mode:
  - 2 CLs have a conflict or they never have
  - A conflict raises only in 1 connected region in the network
- Ports are nodes & CLs are links in the conflict-multigraph
- A fast greedy-heuristics colors the edges of the graph (better heuristics can be executed with critical switches)
- CLs with the same color can be executed concurrently
- 4000 CLs can be colored within 5sec on a standard-laptop



Calculate offline-schedules; Synchronization
- Each color represents one time-slot
- The synchronization of the schedules is done by permutation of whole time-slots
- Non-RT traffic can be executed in arising empty slots and in added new slots



4 Ways of Implementing the Schedules

- One central arbiter; global schedule
- One arbiter at each switch; local schedules
- Schedules integrated into the switches; polling
- Schedules in the switches & synch. devices

Frank Dopatka, Roland Wismüller - 57068 Siegen, Germany - http://www.bs.informatik.uni-siegen.de/ - frank.dopatka@uni-siegen.de