Retis
Real-Time Systems Laboratory

Wireless Real-Time Communication Framework for Mobile Robots

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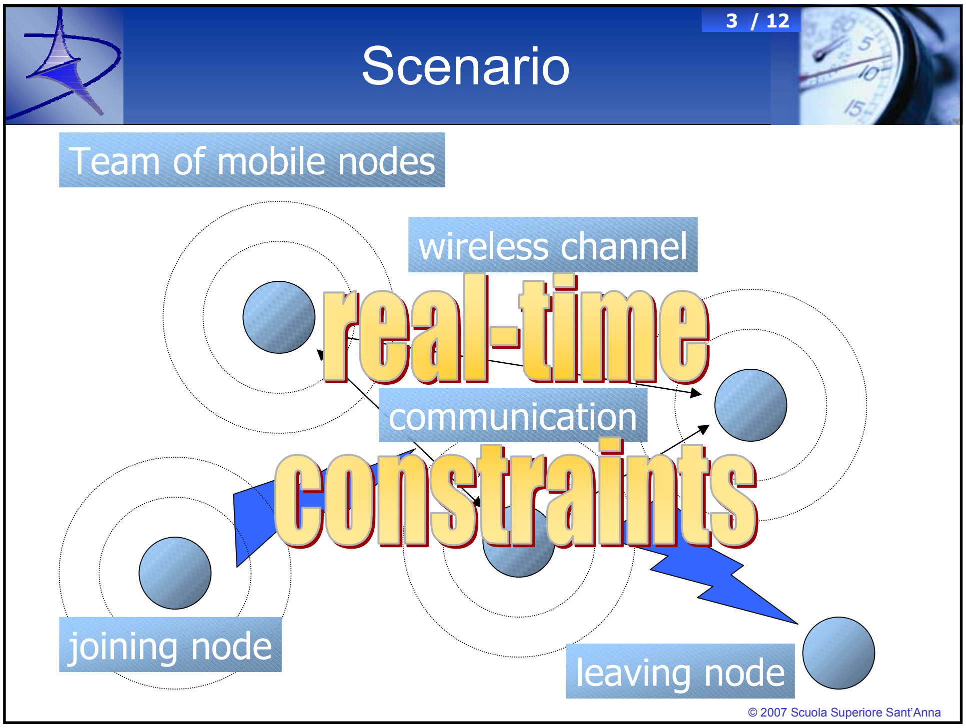
Contribution

Communication
- guaranteed real-time periodic message broadcasting

Network reconfiguration
- add/remove nodes
- change bandwidth requirements
- change transmission frequency

Connectivity tracking
- support of the network reconfiguration
- packet routing
- power-aware communication
- improve spatial bandwidth usage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Scenario
Team of mobile nodes
wireless channel
real-time
communication
constraints
joining node
leaving node
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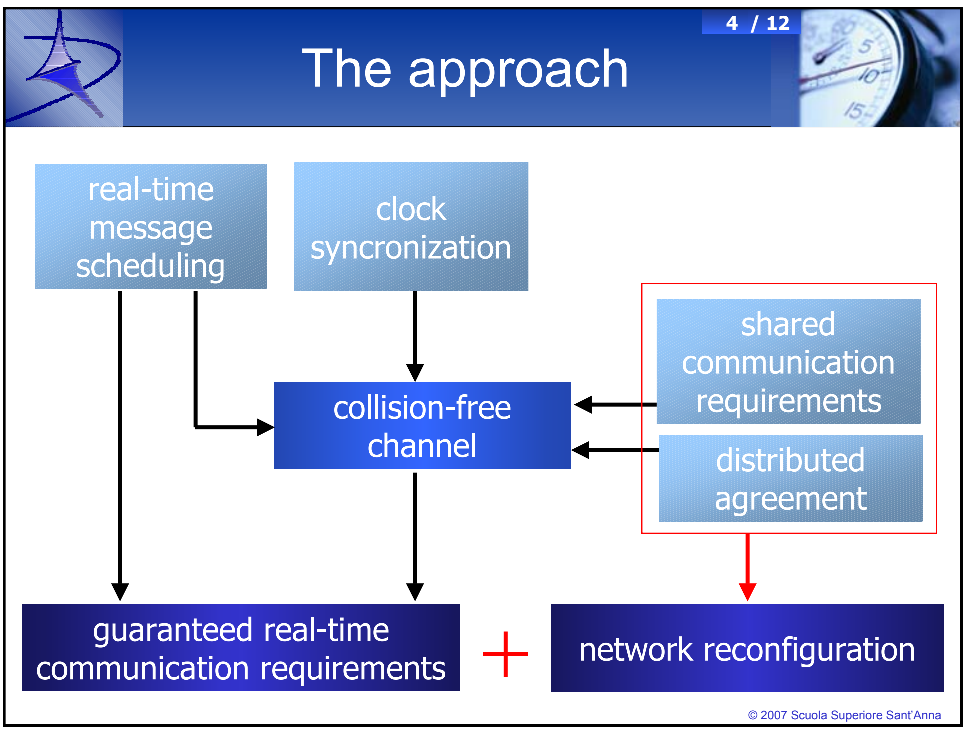
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The approach
real-time message scheduling
clock syncronization
shared communication requirements
collision-free channel
distributed agreement
guaranteed real-time communication requirements
+
network reconfiguration
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Features

Cooperative

- nodes collaborate to achieve the common goal
- decisions must be agreed by all the nodes

Distributed

- no special nodes (master)
- all nodes have the same relevance in the network
- absence of centralized sources of failure

Agreement: about what?

- to let an external node join the team
- to exclude a node from the team (i.e., due to crash)
- to dynamically adapt the communication requirements (bandwidth adaptation, new streams)
- to change the scheduling order of the sync message (improve efficiency)
- to change the communication frequency (due to noise or interference)

Results

- convergence of the agreement process
- determination of the worst topology in case of bi-directional and uni-directional links
- determination of the time required for the agreement in case of worst topology
- verification of the bound in case of time-invariant topologies and no errors
- study of the performance in case of transmission errors and random node mobility (random waypoint, gauss-markov)

Connectivity tracking

- based on a connectivity matrix
- update algoritm which guarantees the convergence of the process
- useful to
  - improve the evaluation on the time required for an agreement
  - detect absent nodes (i.e., crashed nodes)
  - plan the nodes mobility
  - reduce the transmission power while achieving a minimum level of connectivity
  - achieve scalability (clustering)
  - increase the spatial bandwidth usage

Basic idea

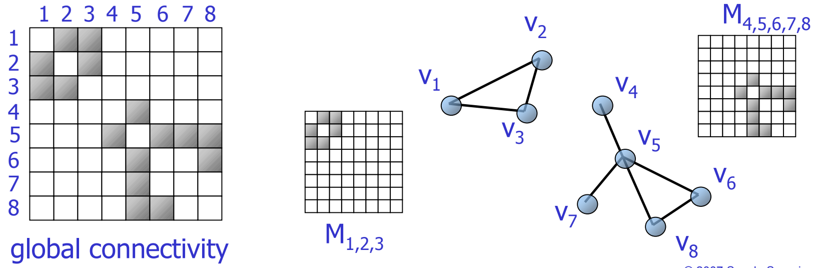
- the matrix is sent as a part of the sync message
- a node update its own matrix on the basis of the received matrix or from a missed reception

> a node v_x uses the information received from node v_y to update the local matrix about a third node v_z only if v_y is closer to v_z (in hops) than the latest node that gave the same information

Convergence

- if the topology does not change for a sufficient time interval

> the connectivity matrix of node v_i converges to the representation of the connected component (disjoint connected subgraph) containing v_i



Simulation results

estimation of the speed of convergence after a change in the topology with no errors

estimation of the speed of convergence

with transmission errors

random node mobility

random waypoint

gauss-markov

Conclusions

- framework for supporting the real-time wireless communication among mobile units
- theoretical results proving several key features of the proposed approach
- simulation results to show the behavior of the approach in realistic situations
- related research topics for further investigation
  - routing
  - topology management
  - power-awareness
  - scalability