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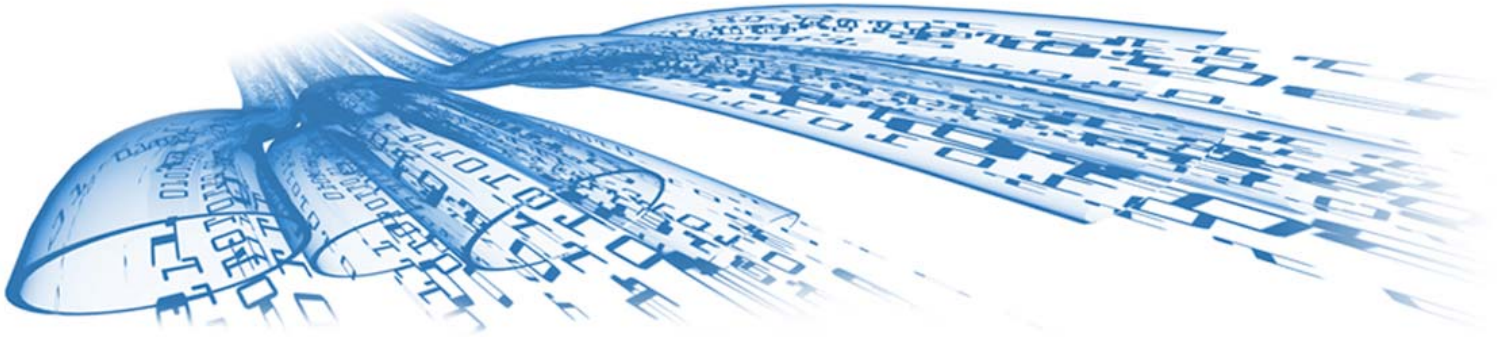

Wireless robotics: issues and the need for standardization

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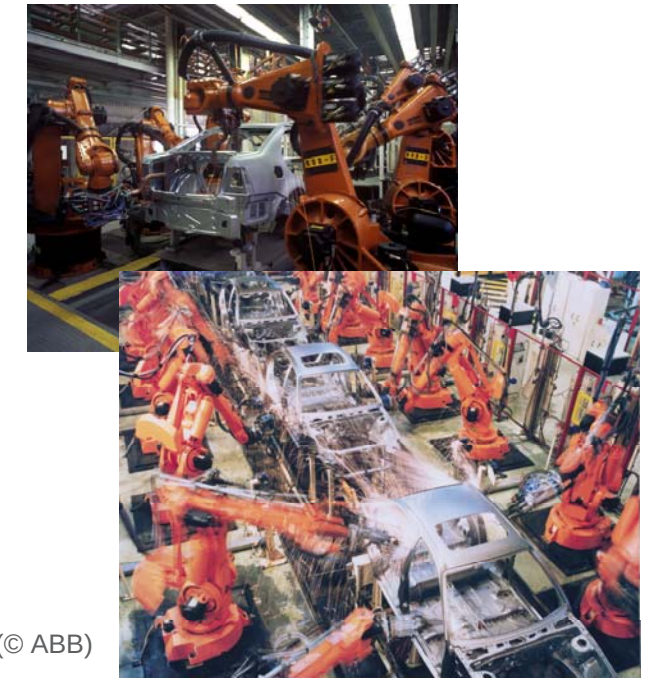
Robots have to operate in diverse environments



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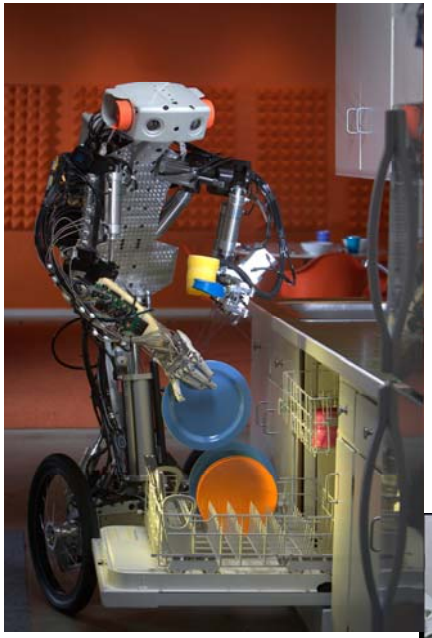

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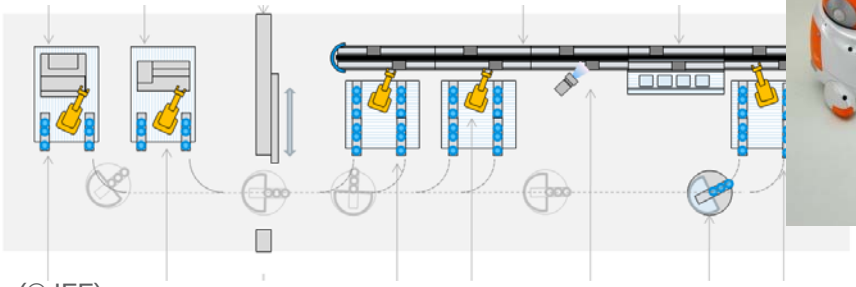

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Basic modes of wireless robot communication

1. Communication between a (mobile) **robot and a fixed base station**, e.g., real-time remote control, robot access to the Internet, contacting the robot from the Internet --> bi-directional control, unidirectional video
2. Communication **between robots**, without a base station, e.g., robots commmunicate directly with one or a (potentially large) number of peers, when they get into transmission reach. Mandatory whenever tasks are to be performed jointly, e.g., jointly carrying a load, but also joint sensory tasks, such as distributed exploration of the environment and map building --> self organizing networks, ad-hoc & wireless sensor networks
3. Communication between the **individual components of the robot** itself. The internal wiring of robots can become very clumsy, even messy and unmanageable – ultimately it may impair the robot's mobility. This is particularly important in the case of humanoid robots with many degrees of freedom and actuators that need to be controlled with timely and highly synchronised commands.

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Common characteristics of robot workspaces

- Permanently and dramatically changing wave propagation conditions
- Typically heavy interference from other radio sources
- Robot setups are highly variable in configuration – from one robot to one base station to multiple robots with multiple access points (which could help each other)
- However: wave propagation can be roughly predicted if robot motion and terrain are known
- If configuration and configuration changes are known, they could in principle be used to improve communications

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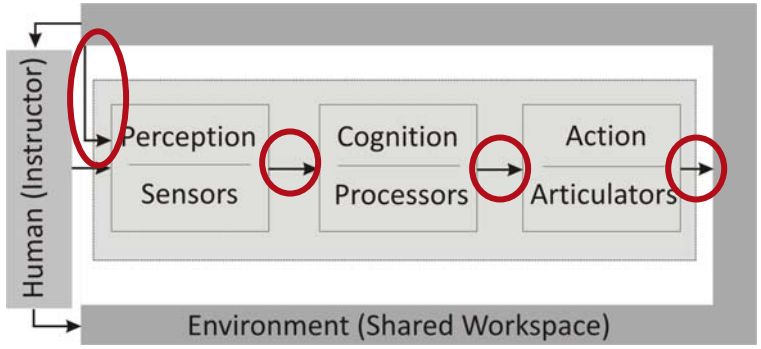
Common requirements for robot communications

- Different use cases for wireless communications in robots (see the red circles: they can all be linked by radio comm.)



- Often, a combination of channels of different bandwidths is desirable (e.g., for narrow-band control and for wide-band video transmission)
- All profiles and all applications depend on a specifiable minimum service quality – but we do not know these yet!

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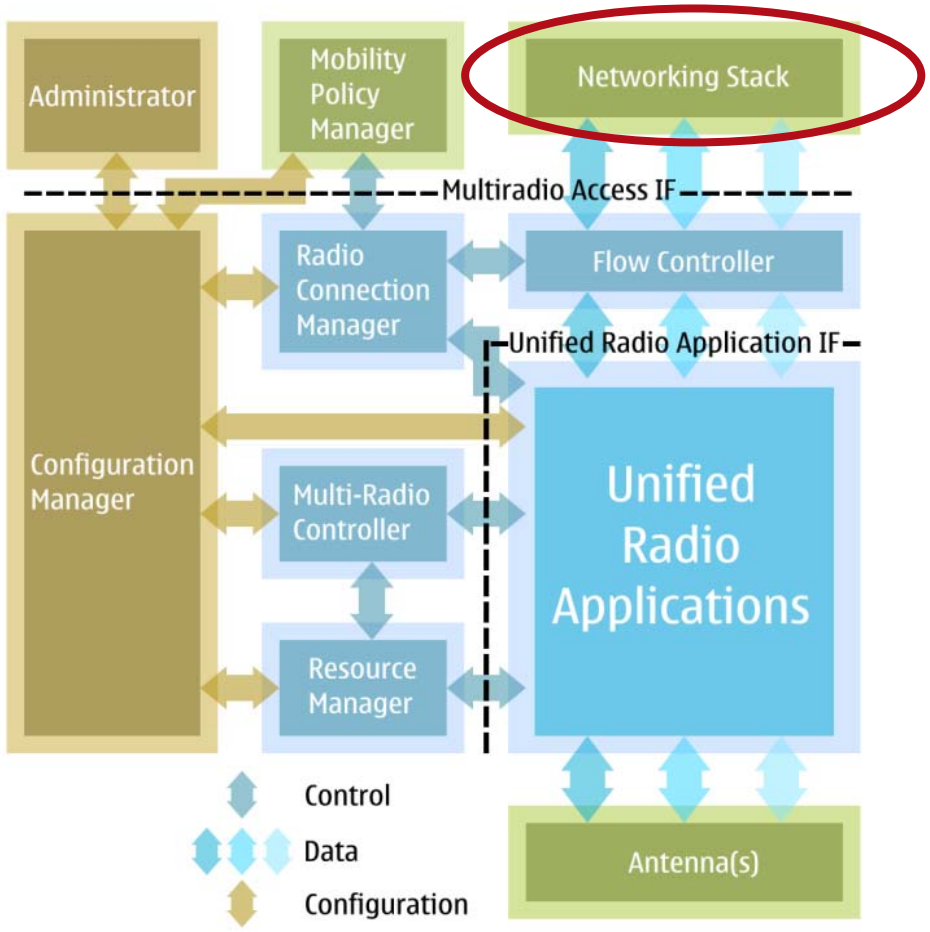
Today: not possible to interface robot control with radio link!

- (Cognitive) Robots know a lot about the environment
- They can also make predictions and influence their strategy to keep radio link alive
- Therefore: close link between network stack layers and radio necessary!



Source: Marcus Mueck, 1st CEPT workshop on Cognitive Radio (CR) and Software Defined Radio (SDR) 12-13 January 2009 – Mainz (Germany)

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Need for standardization I

- Multitude of standards for radio interfaces available
- But:
  - they were not (primarily) designed with QoS requirements in mind: latency, minimum bandwidth, recovery strategies
  - they do not interact with the upper layers of robot control
  - they do not take into account the possibility of rapidly changing environmental conditions
  - they are not certifiable for reliability, availability, fault tolerance
  - they cannot cope with changing network configurations (e.g., “disappearing base station”)
  - they are not tailored to roaming with varying functional requirements (e.g., when a robot moves from indoor to outdoor and must change to “autonomous mode”)

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Need for standardization II

- Suggested Procedure:
  - Specification of typical profiles for robot radio link usage, Studies of wave/EMC conditions in these use cases,
  - Specification of desirable QoS
  - Exploration of domain-specific deficiencies of today's technologies/protocols/standards
  - Extraction of useful parts of existing standards and fusion and/or modification
  - Development of demonstrator scenarios for all profiles and for all the use cases
  - Start of a number of iteration rounds and dissemination into the robotics and networking community – based on the demonstrations

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