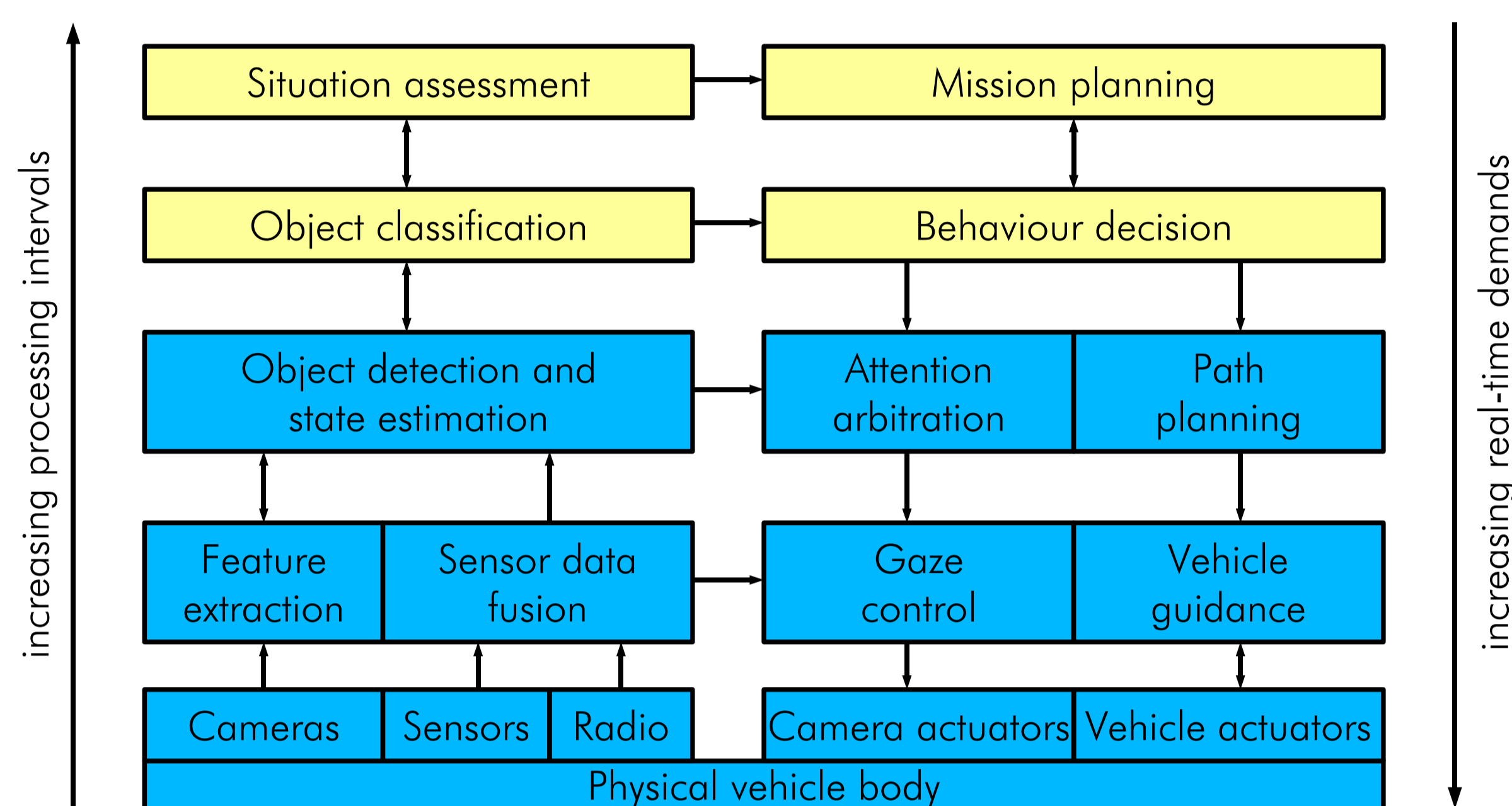


A Real-Time-capable Hard- and Software Architecture for Joint Image and Knowledge Processing in Cognitive Automobiles

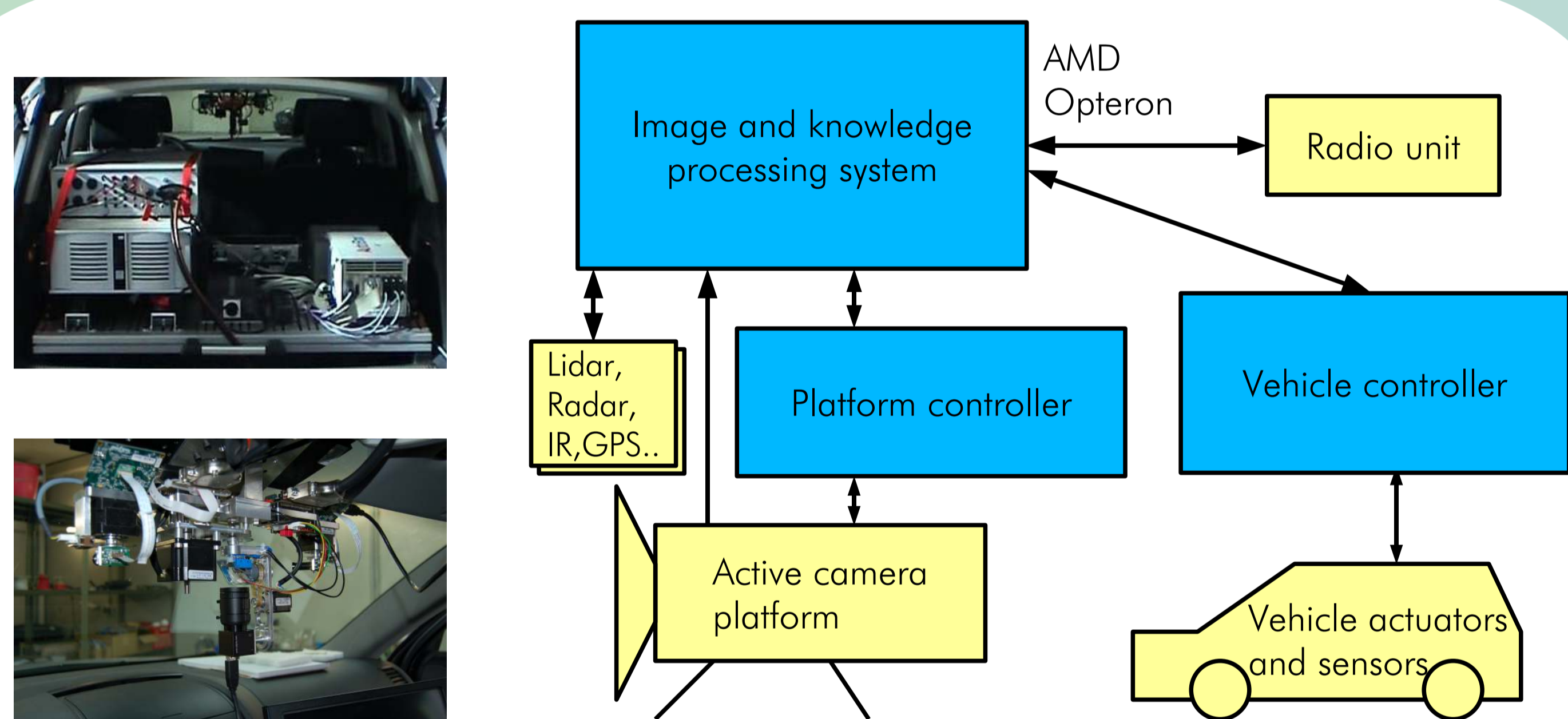
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Functional Architecture

- Architectural requirements of cognitive automobiles:
 - Distinct levels of information processing with specific temporal resolutions and real-time requirements
 - Extensive information needs by all software modules for subsequent data fusion and verification
 - Combination of algorithms with different approaches
- Functional overview:



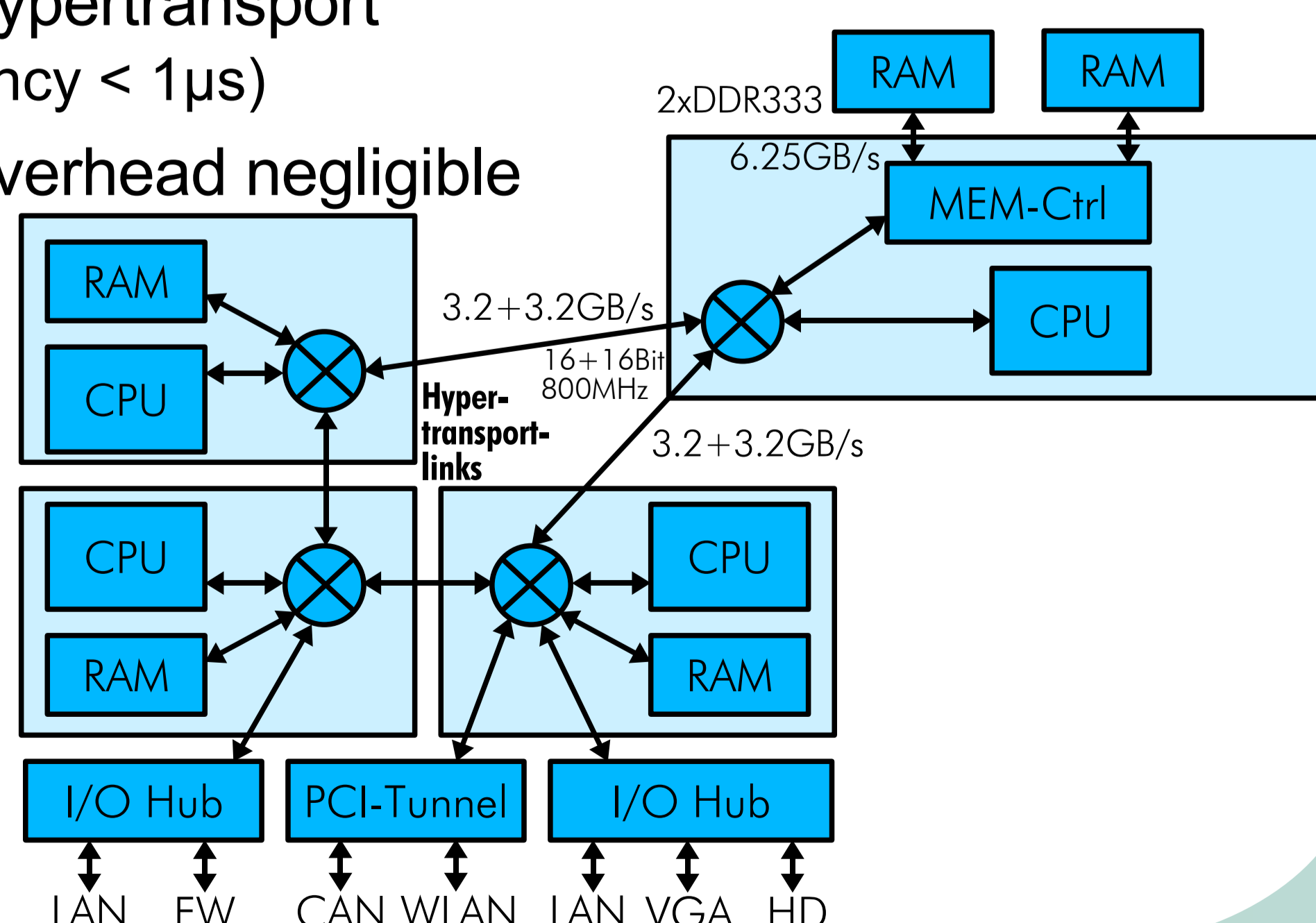
Hardware Architecture



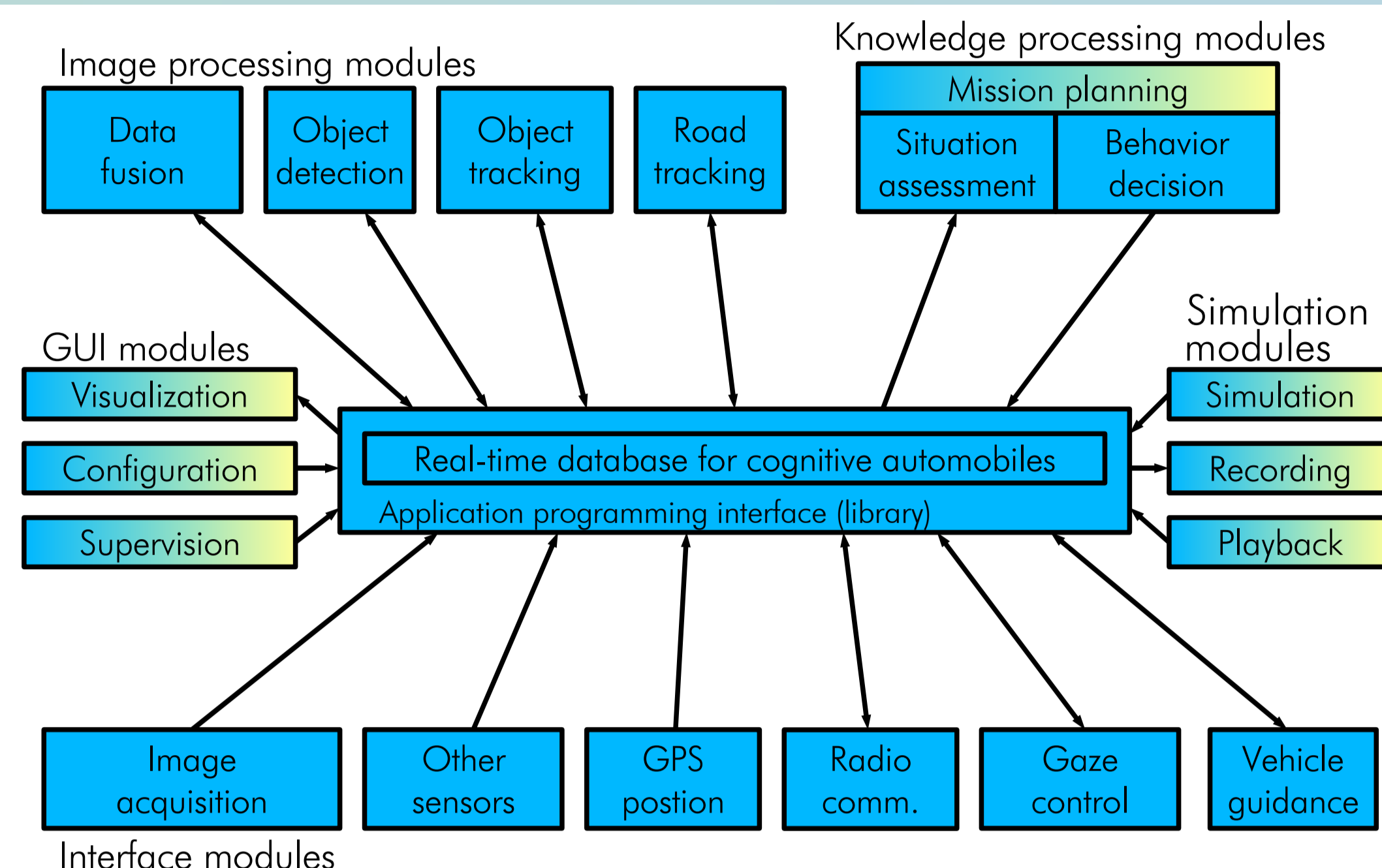
- Selected multicore multiprocessor system provides:
 - Fast computation for image processing
 - I/O bandwidth for image and sensor data acquisition
 - Large memory for knowledge processing
 - Parallel execution of cognitive functions
 - Low latencies for interprocess communication
 - Powerful storage for logging (RAID, Flash)

- AMD Opteron regarded as „Cluster-in-a-box“:

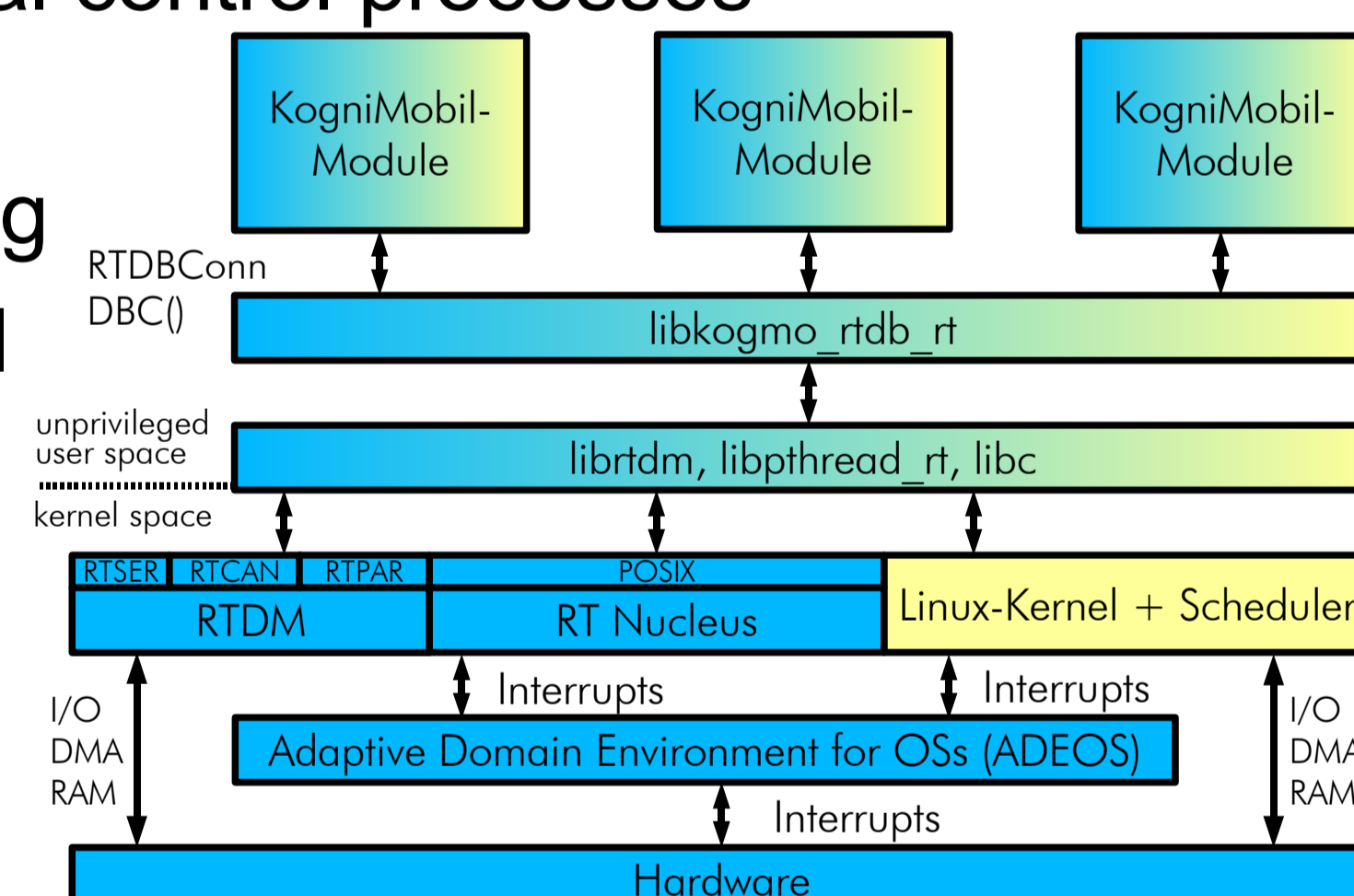
- CPU's linked by Hypertransport (3.2·10⁹ byte/s, latency < 1µs)
- Communication overhead negligible
- Easy duplication
- Affordable price
- Single infrastructure components
- 160W (2x275HE)



Software Architecture



- Real-time database „KogMo-RTDB“ as integration framework:
 - Central publication of relevant information (raw sensor data, tracked objects, situation and generated behavior)
 - Open access for maximum transparency between all cognitive layers
 - Unified interface also for simulation and situation replay
 - Intuitive API that provides methods to
 - publish and update own data objects
 - search and retrieve objects from other modules
 - wait for updated data and new objects by others (trigger)
 - Temporal decoupling with history buffers and consequent use of timestamps for submitting and querying objects
 - Coherent view at the situation for slower modules
- Seamless integration of real-time and non real-time modules :
 - Hard real-time for critical control processes
 - No interference from visualisation and logging
 - Lock-less write protocol prevents blocking
 - Dynamic switch to real-time mode to prevent priority inversion



Experimental Results

- Comprehensive architecture used in several vehicles
- Powerful integration platform for tight cooperation of all cognitive modules
- Measurement results of key operations show:
 - Low overhead
 - Fast response
 - Guaranteed real-time

Operation (heavy load)	Time (average, min-max, in µs)	
	non real-time	real-time
Insert	122.5, 39- 93109	75.6, 38-273
Delete	18.5, 4- 41250	18.5, 8-131
WriteData	22.6, 5-181681	25.6, 6-134
ReadData	17.0, 4- 10721	16.8, 4-62
IPC-Latency	169.8, 20- 36129	66.5, 21-208

