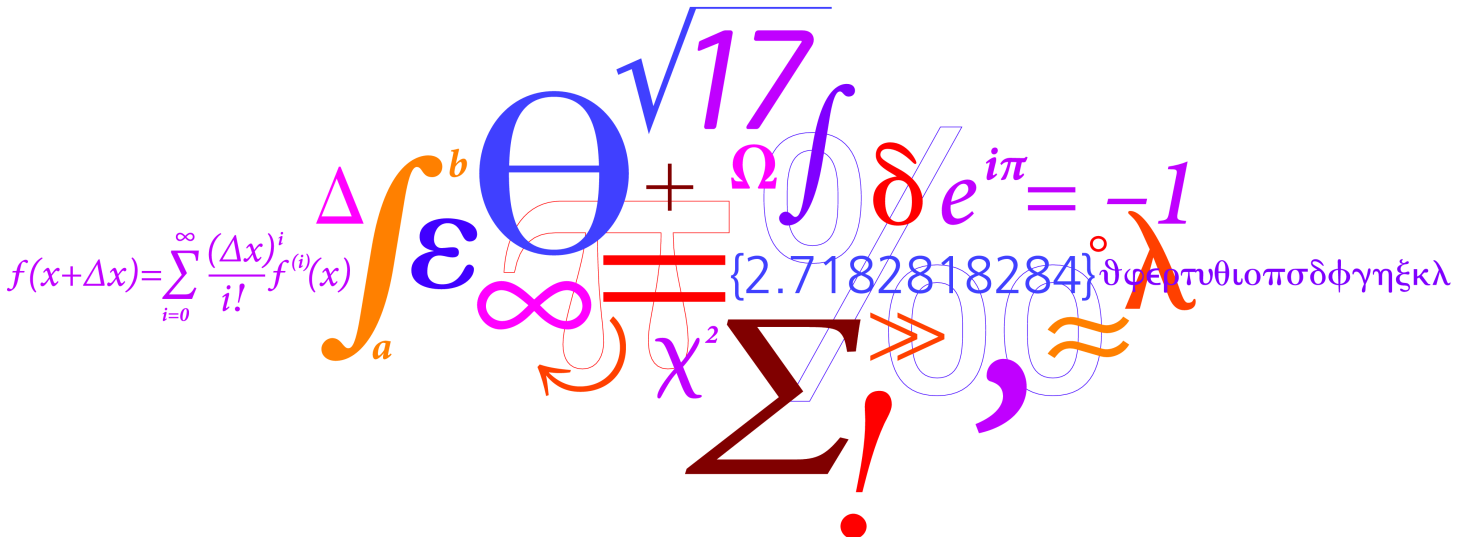
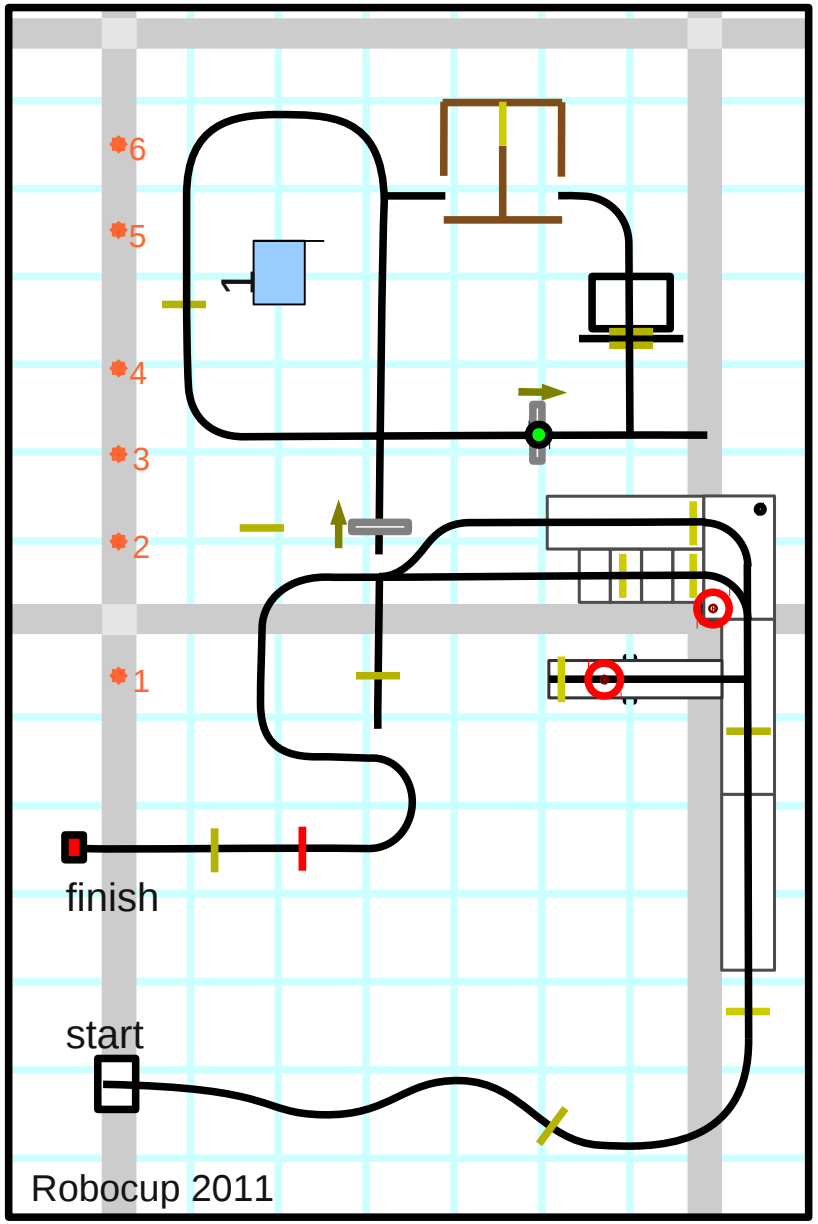
Software architecture

- Robot control architecture
  - Serial
  - Parallel
  - Temporal-abstraction (NASREM)
- Software architecture
  - Cohesion, modularity
- Mobotware architecture
  - MRC and tactical mission script
  - Complex architecture and strategic missions
- Sample architecture – S+R project



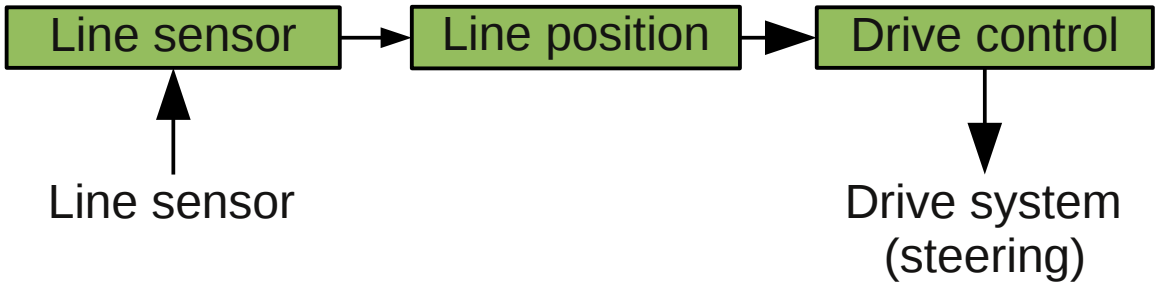
Serial decomposition



Dr.Demo

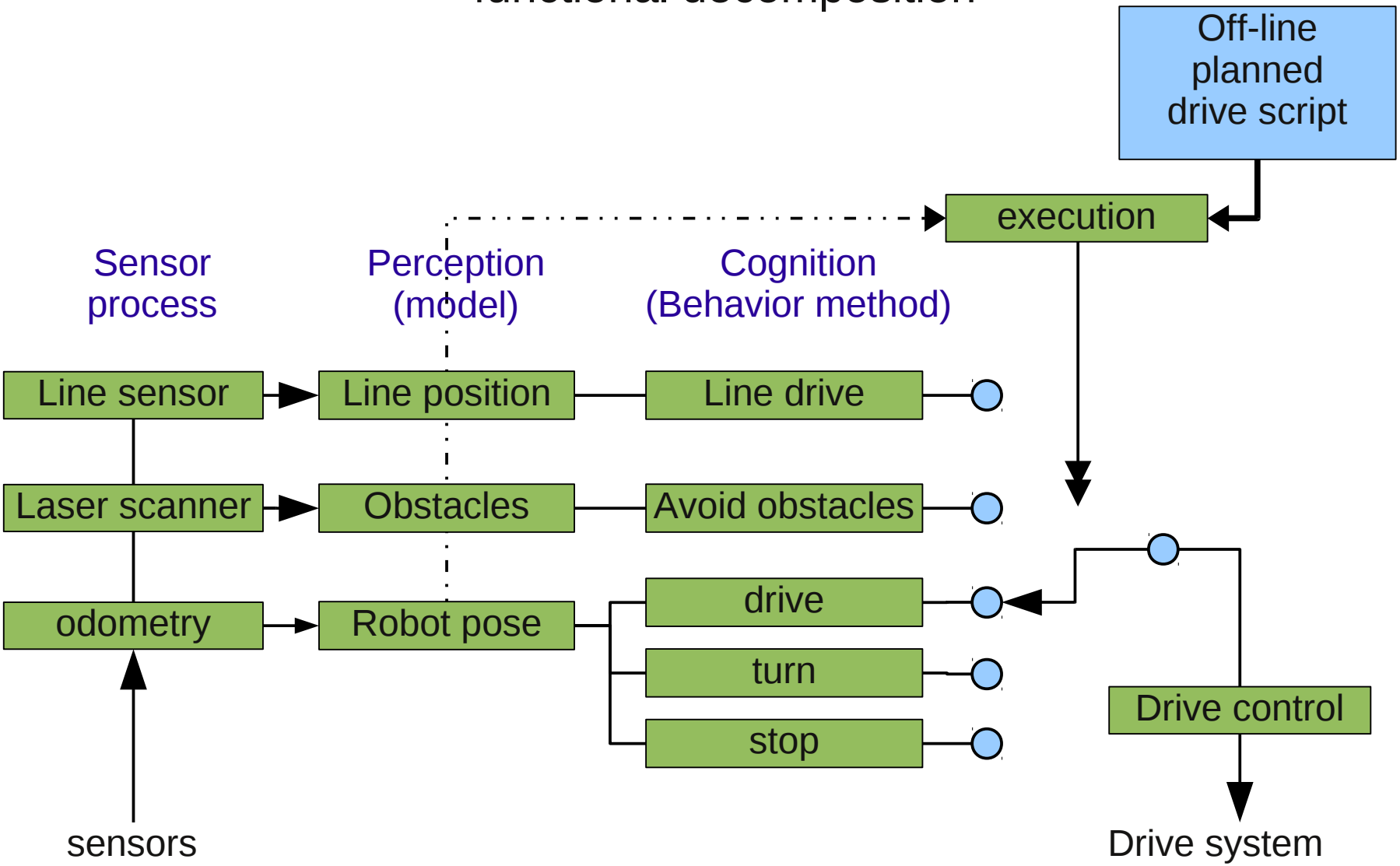
Simple, stable, predictable robot control architecture

Serial functional decomposition



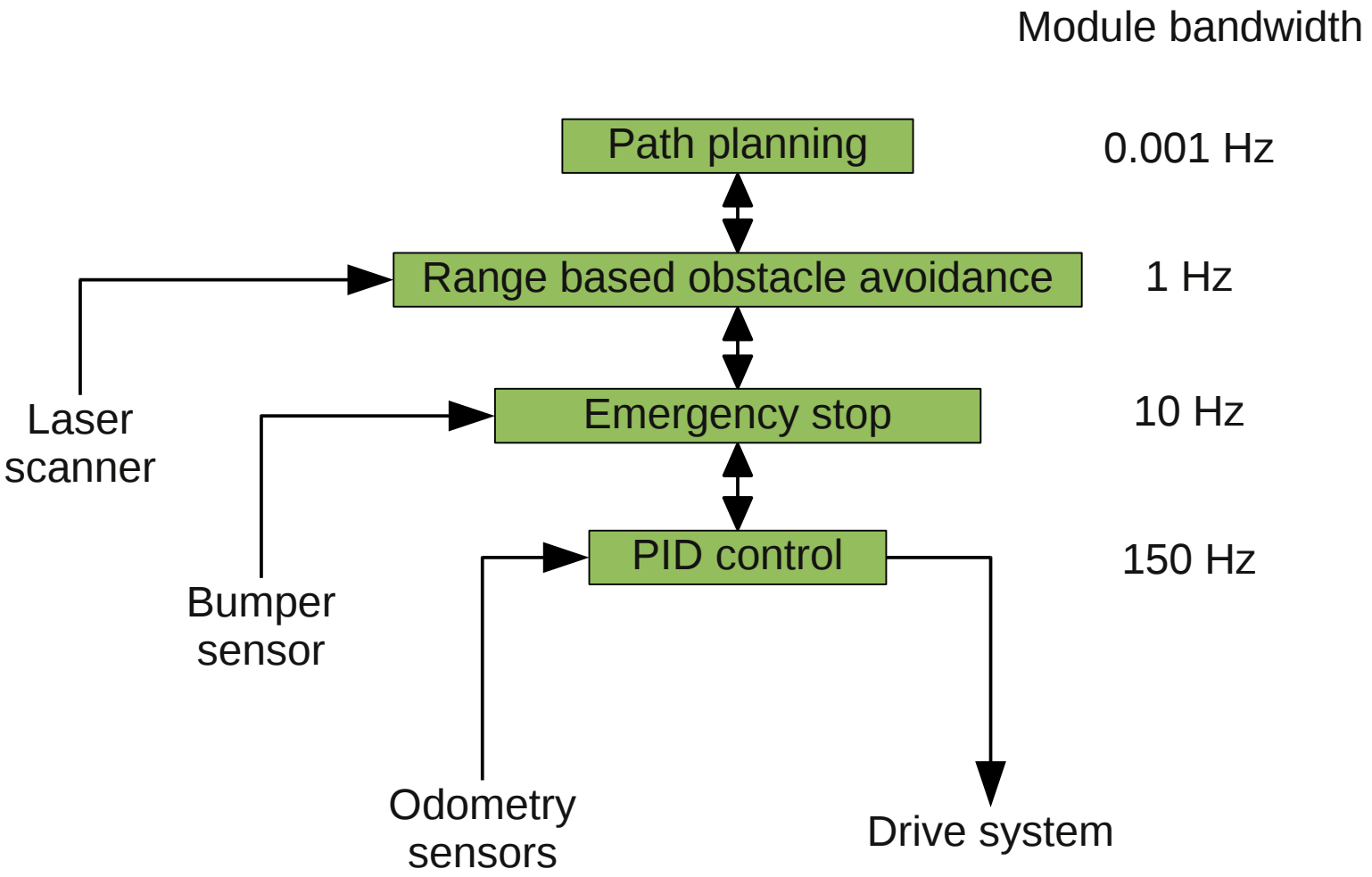
Parallel – serial

functional decomposition



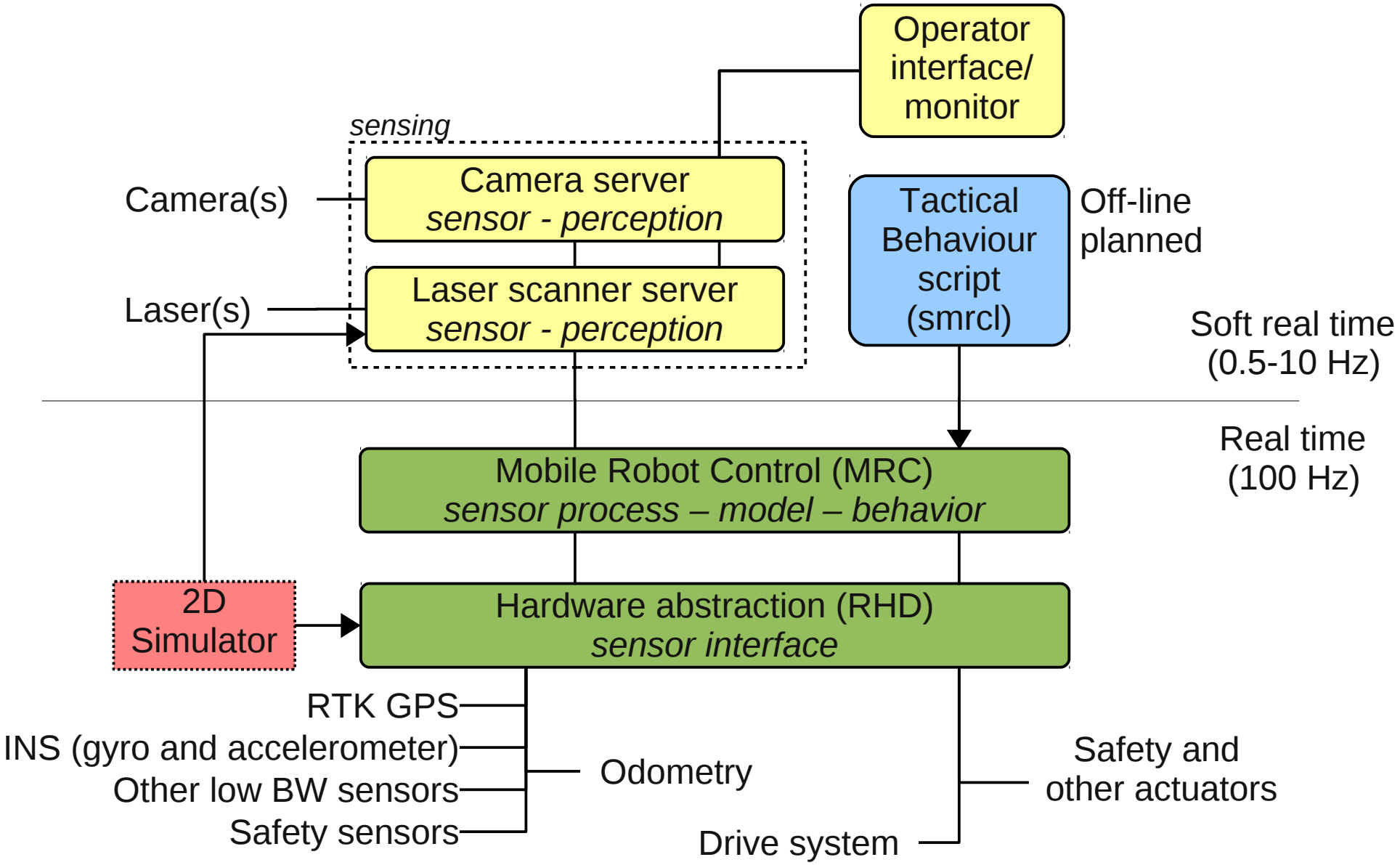
Flexible planning that copes in diverse environment (sequential or state based).
Unforeseen events: obstacles while doing line drive? Emergency stop?

Temporal decomposition

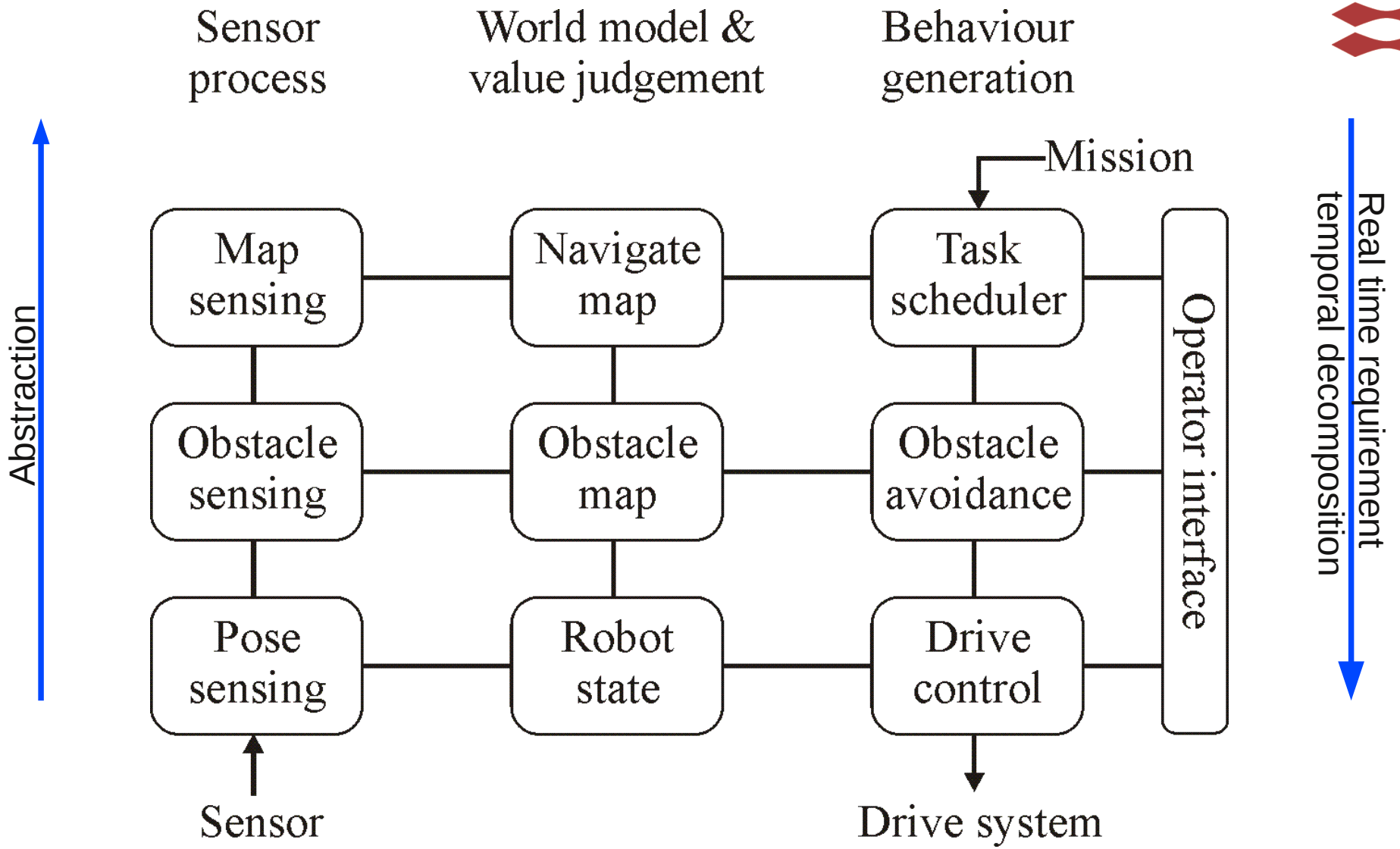


New path every mission, modify for obstacle avoid, react on unforeseen events, tight drive control.
Useful for “potential field path planning”?

Real architecture – MRC script



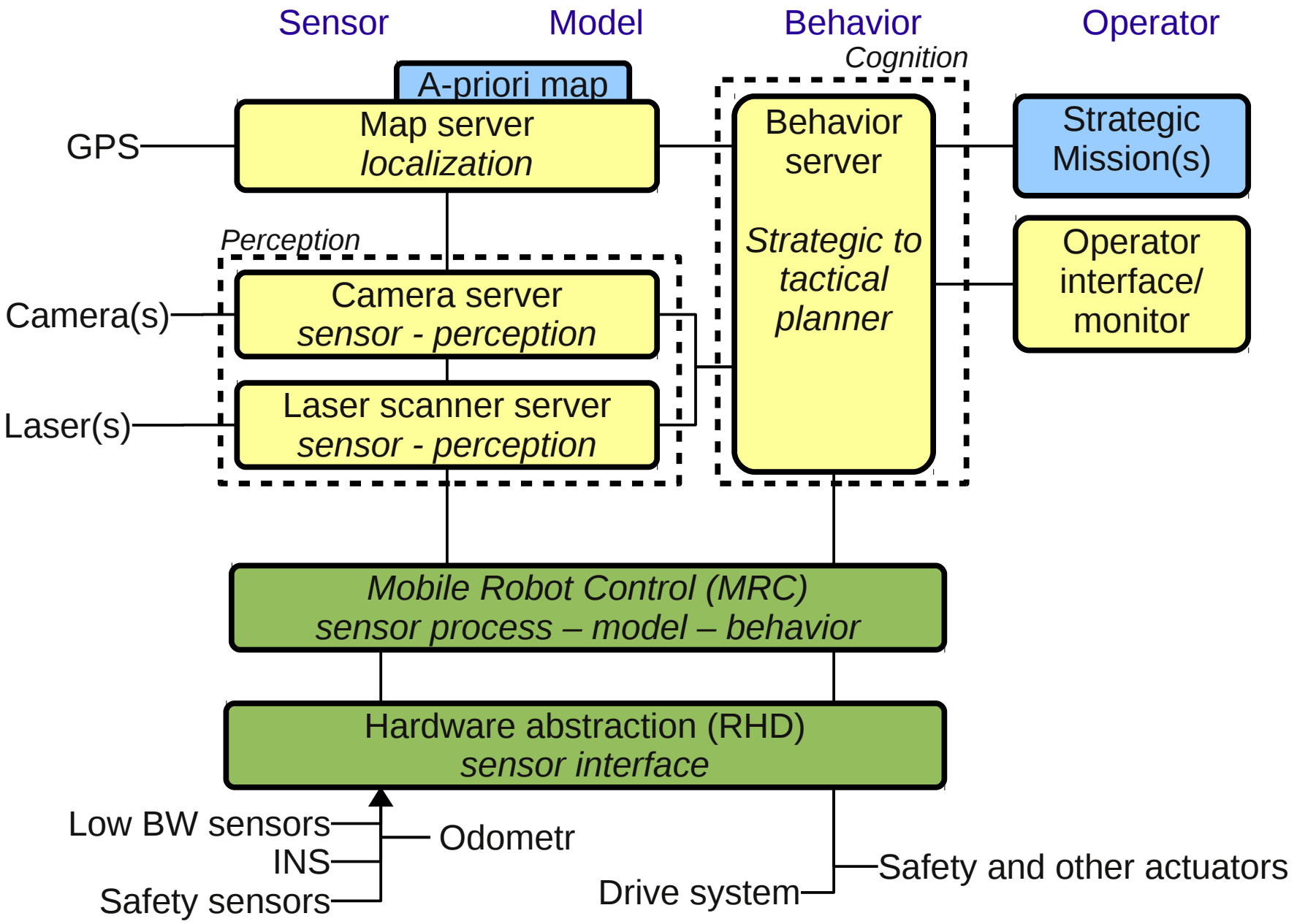
Robot model (NASREM)



ref: **NASREM**

The National Aeronautics and Space Administration (NASA) and the US National Institute of Standards and Technology (NIST) have developed a Standard Reference Model Telerobot Control System Architecture (NASREM). Albus, J. S. (1992), A reference model architecture for intelligent systems design.

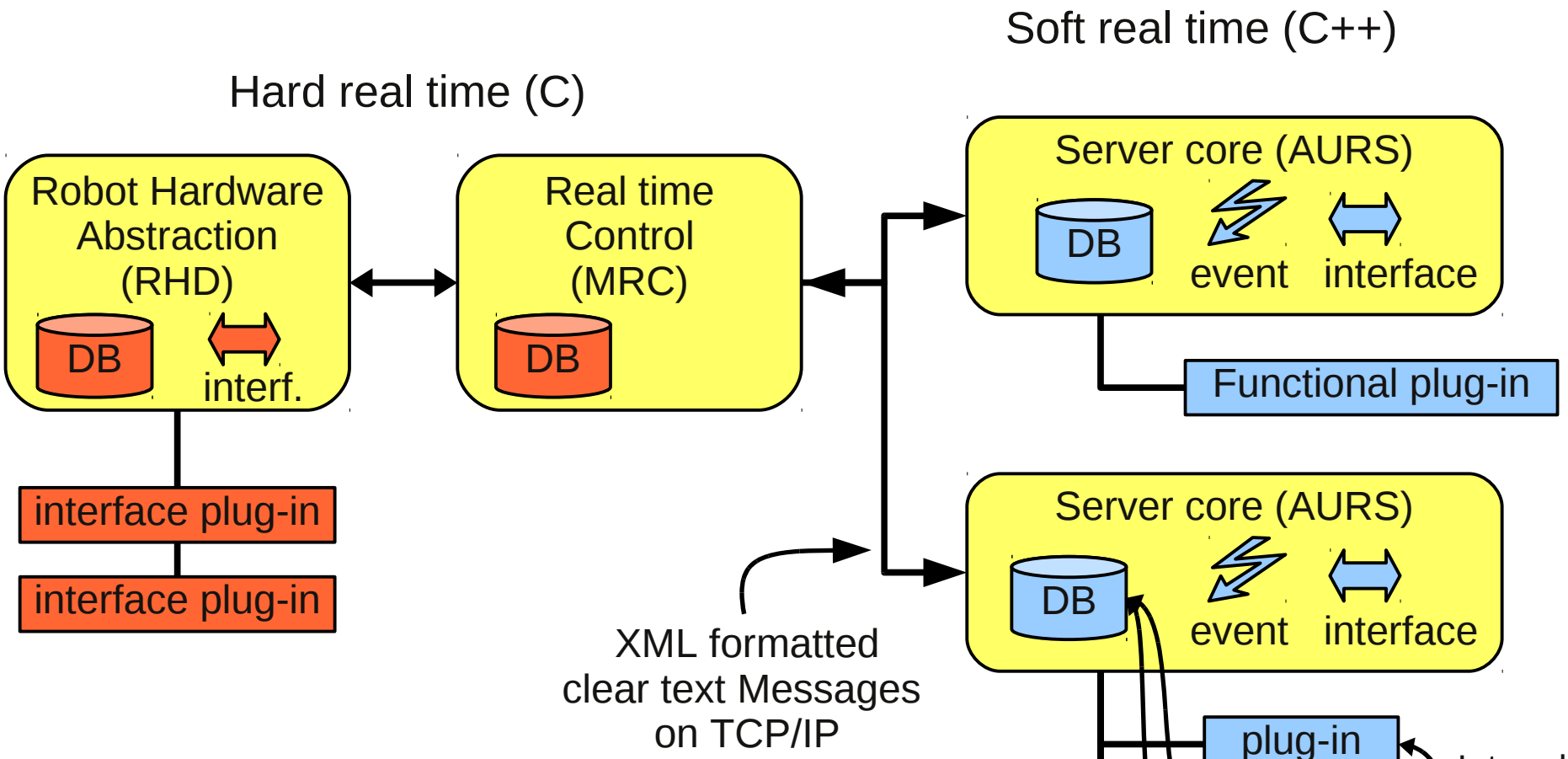
Mobotware-2


Sensor
Model
Behavior
Operator
Cognition
A-priori map
Map server
localization
GPS
Behavior
server
Strategic to
tactical
planner
Strategic
Mission(s)
Operator
interface/
monitor
Perception
Camera server
sensor - perception
Camera(s)
Laser scanner server
sensor - perception
Laser(s)
Real time requirement
temporal decomposition
Mobile Robot Control (MRC)
sensor process – model – behavior
Hardware abstraction (RHD)
sensor interface
Low BW sensors
INS
Safety sensors
Odometr
Drive system
Safety and other actuators

Software architecture

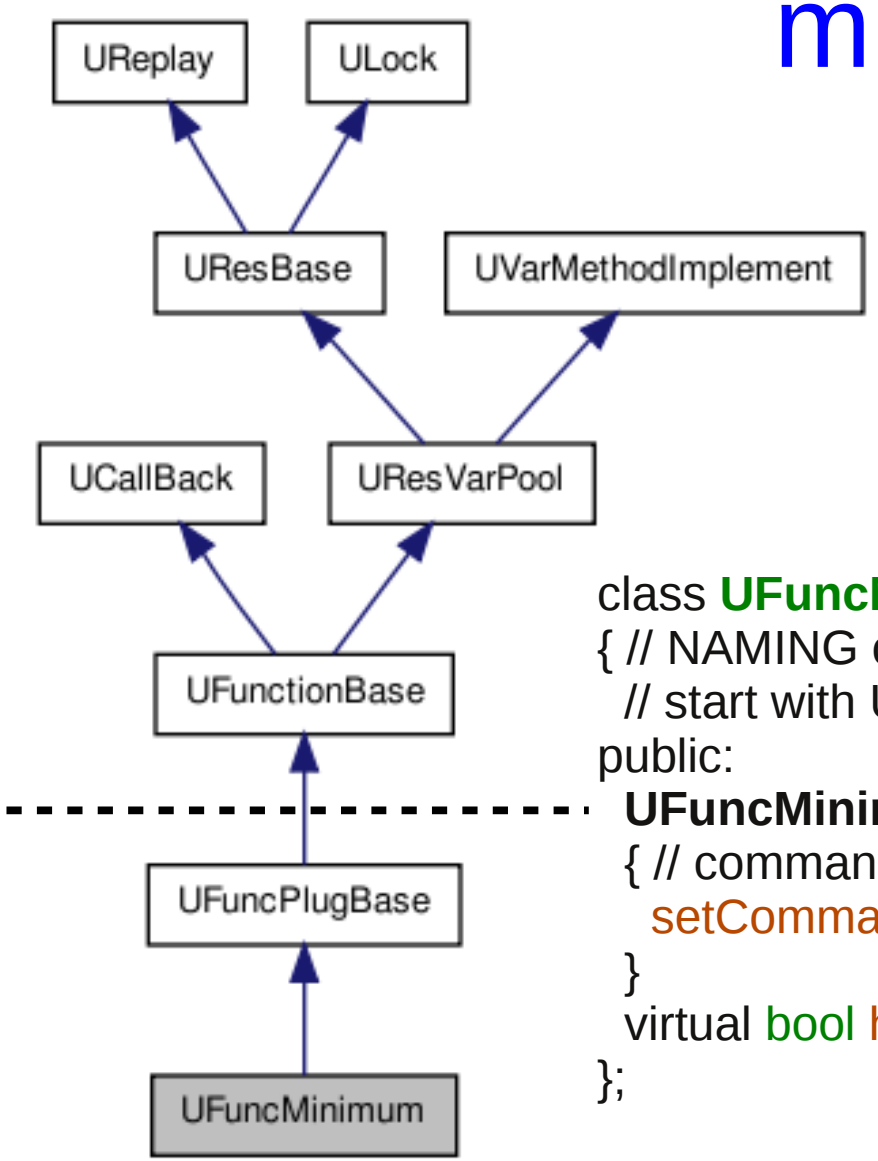
- Modularity
  - Distributed development, debug
  - e.g. libraries and plug-in modules
- Cohesion and coupling
  - High cohesion for *understandable, reusable, testable code*
    - Functional (e.g. localization)
    - Temporal (e.g. real time control loop)
    - Communicational (e.g. image processing)
  - Low coupling for *minimal interdependency*
    - Message and data sharing (not control or local data structures)
- Distributed
  - Failure tolerance
    - Failure of one process can be detected by another
  - Processing
    - Isolate real-time from lengthy processing
- Event and data driven
  - Events: sensor data or derived detections (action, state machine)
  - Database: system state, configuration, reasoning rules
    (continued data analysis and data generation)

Mobotware software architecture



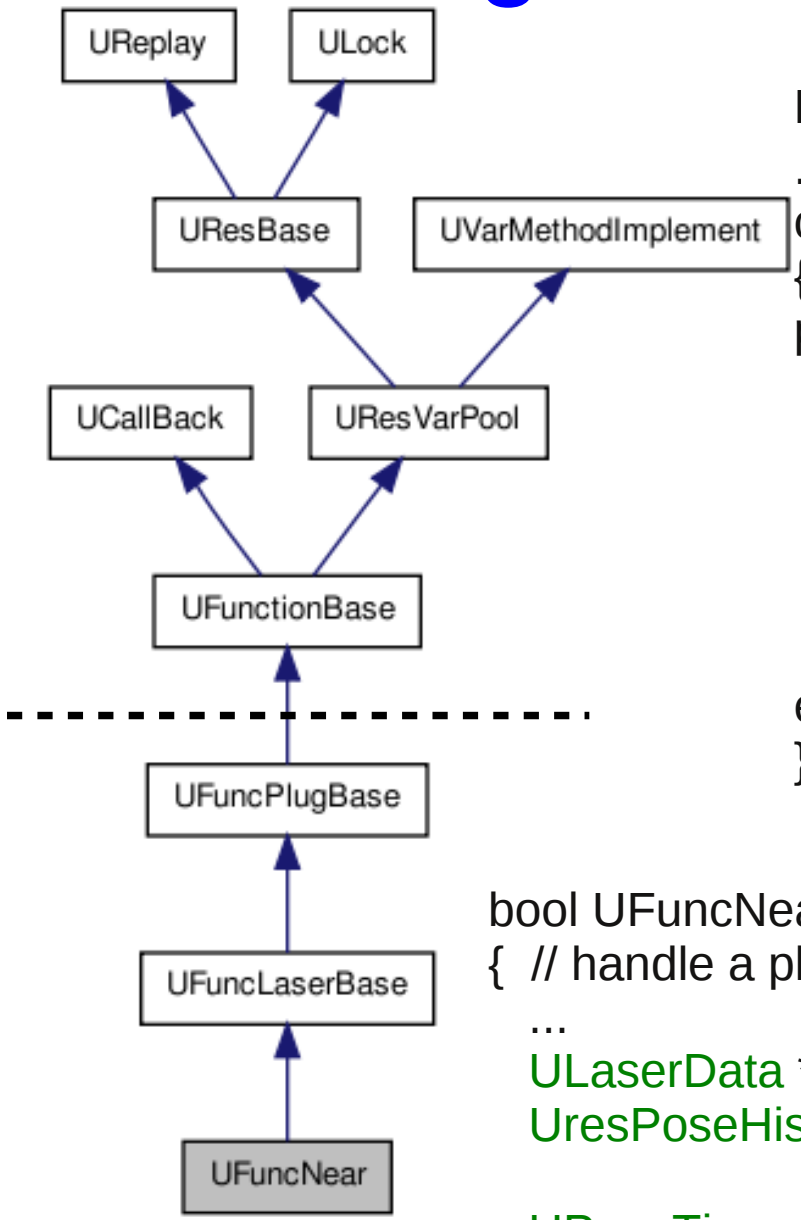
- Modular (distributed and plug-in based)
- Cohesion (temporal, functional and object oriented)
- Low coupling (XML and DB)
- Event and data driven

AURS Plug-in structure - minimum




```
class UFuncMinimum : public UFuncPlugBase
{ // NAMING convention:
  // start with UFunc (as in UFuncMinimum)
public:
  UFuncMinimum()
  { // command list (space separated) descriptive short text
    setCommand("minimum", "minimum", "plugin examples");
  }
  virtual bool handleCommand(UServerInMsg * msg, void * extra);
};
```

Plug-in structure - laser



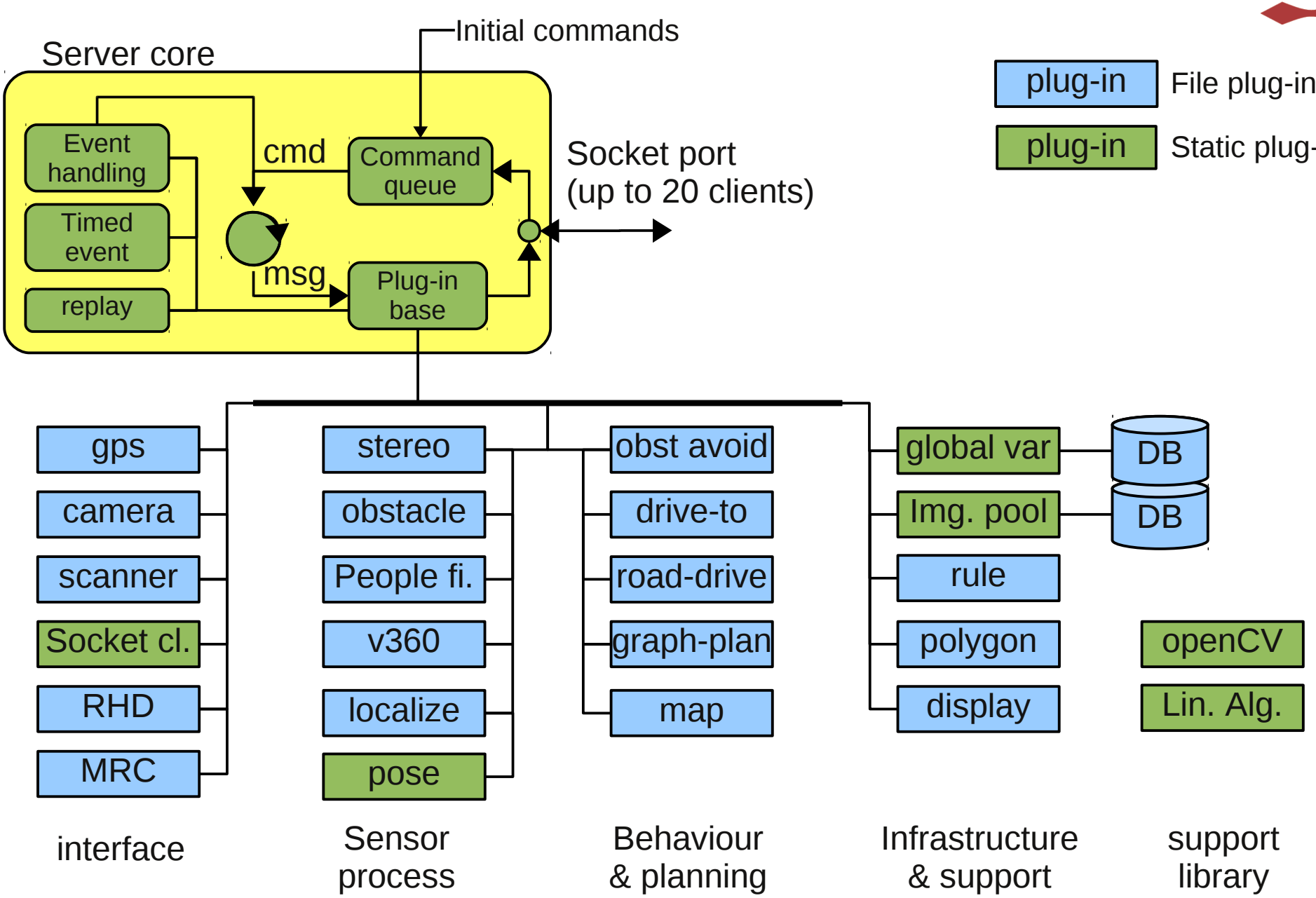
Part of ./examples/aulmsnear/ufuncnear.h

```
...
class UFuncNear : public UFuncLaserBase
{
public:
  UFuncNear()  {
    setCommand("near nearget", "laserNearGet",
                        "get positions from laserscan");
  }
  virtual bool
  handleCommand(UServerInMsg * msg, void *
extra);
};
```

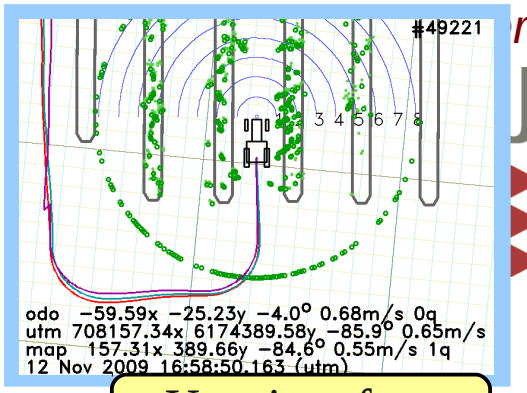
implementation

```
bool UFuncNear::handleCommand(UServerInMsg * msg, void * extra)
{  // handle a plugin command
   ...
   ULaserData * data = getScan(msg, (ULaserData*)extra);
   UresPoseHist * odoPose = (UResPoseHist *)
                              getStaticResource("odoPose", true);
   UPoseTime   pose = odoPose->getNewest();
   ...
```

Server structure (AURS)



S+R project



Perception processor

Camera server 24920
Stereo device
odoPose
3D obst
if

State keeper 24926
rule
if

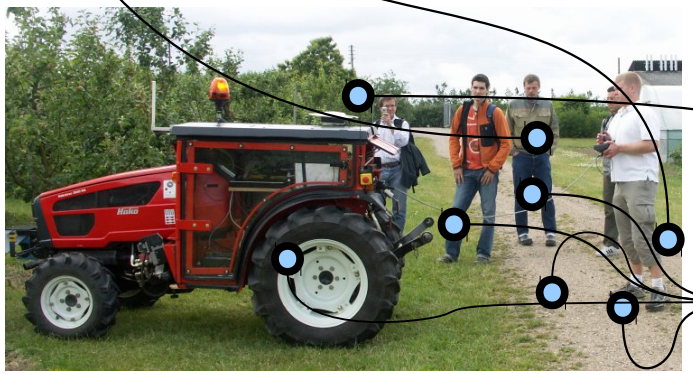
Laser server 24919
Laser obst
Virt. 360 deg
Laser device
Map pose
Localizer
rule
A-priori map
if

Behaviour server 24922
A-priori map
Odo pose
GPS/odo pose
Obstacle base
if
Drive pos
Obst. avoid
Rule
MRC -if.

User interface 24929
disp
if

Wireless router + switch

TCP/IP - ethernet



ESX

State keeper 24926
rule
if

MRC 31001

RHD 24902

RTK GPS

Canbus

Navigation processor

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