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An approach to distributed remote control based on middleware technology, MATLAB/Simulink - LabMap/LabNet framework

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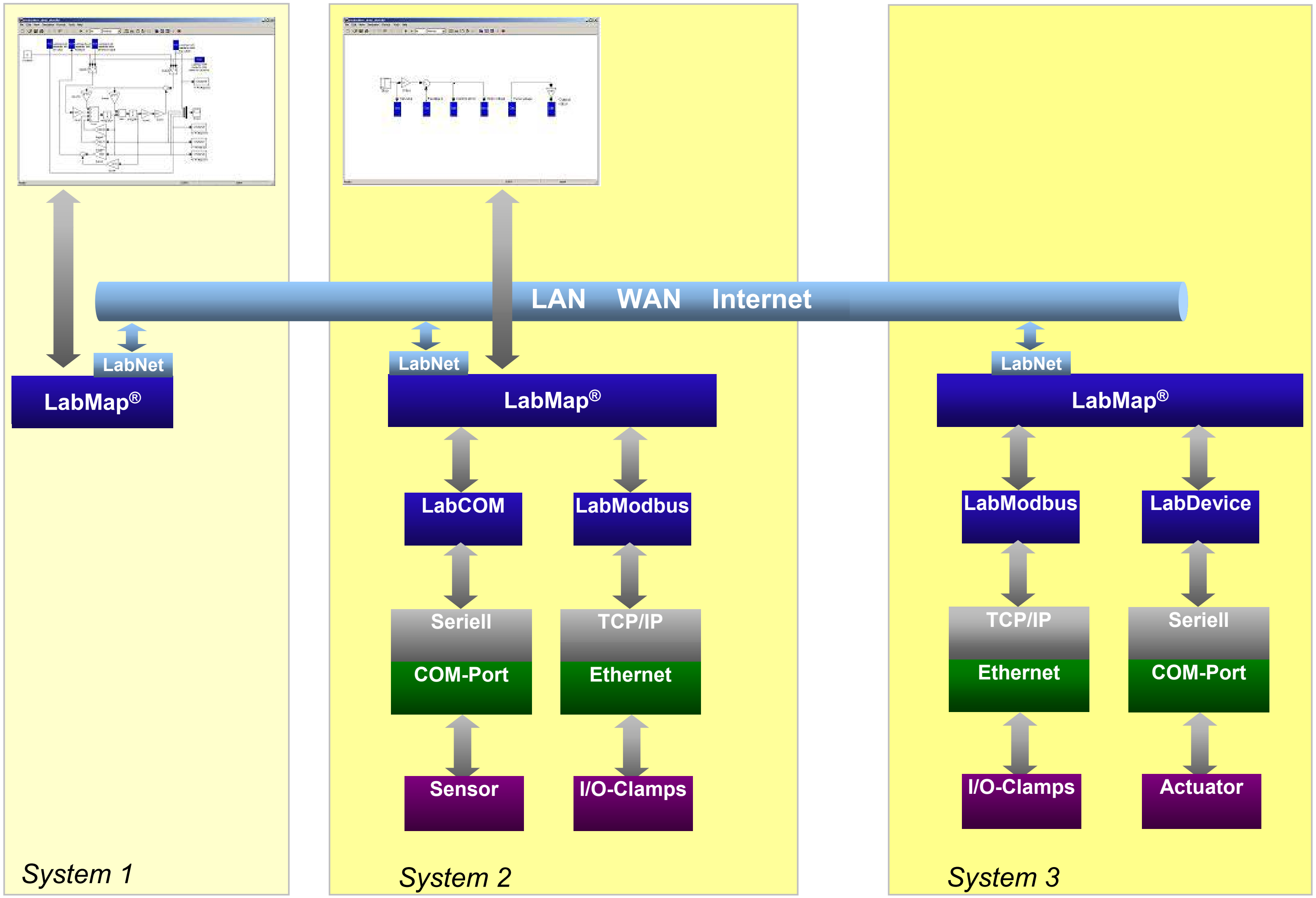
Introduction

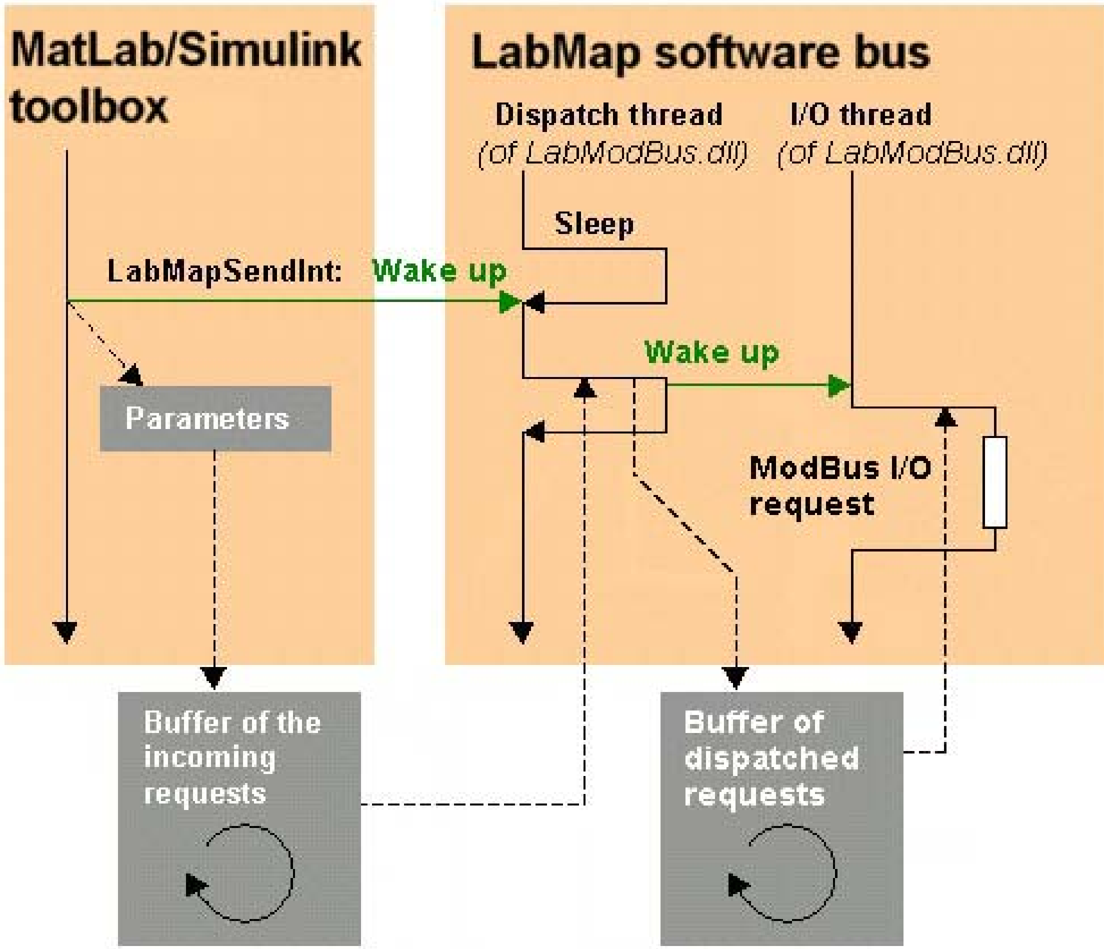
Roles of middleware

- **Distribution**
  data across the system partitions
  control both logically and physically
- **Integration**
  heterogeneous hardware protocols
  software components
- **Abstraction**
  application logic from the hardware
  data from its sources, such as in simulation
- **Decoupling**
  software components
  the system is viewed as a set of variables

LabMap in a distributed system



Messaging in LabMap



Views on variables

- **Name, Value, Dimension**
- **Time stamp**

  universal coordinated time (UTC)
- **Bounds**

  checkable value ranges

  enforceable value ranges
- **Status**

  errors

  pending I/O

Policies for requesting data

- **Application controlled**
  triggered by the application

- **Periodic**
  periodically requested from or issued by the hardware
  checkable time constraint (the period)

- **Event controlled**
  as above, but only value changes are taken into account
  time constraint is ignored

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Access operations on variables

- **Get**
  the current value and / or time stamp

- **Set**
  the new value and time stamp locally

- **Request**
  a new value from the hardware, asynchronously

- **Send**
  a new time-stamped value down to the hardware, asynchronously

Notification services

- **Wait for I/O completion**
  non-busy waiting

- **Wait for a new value**
  non-busy waiting for a value update

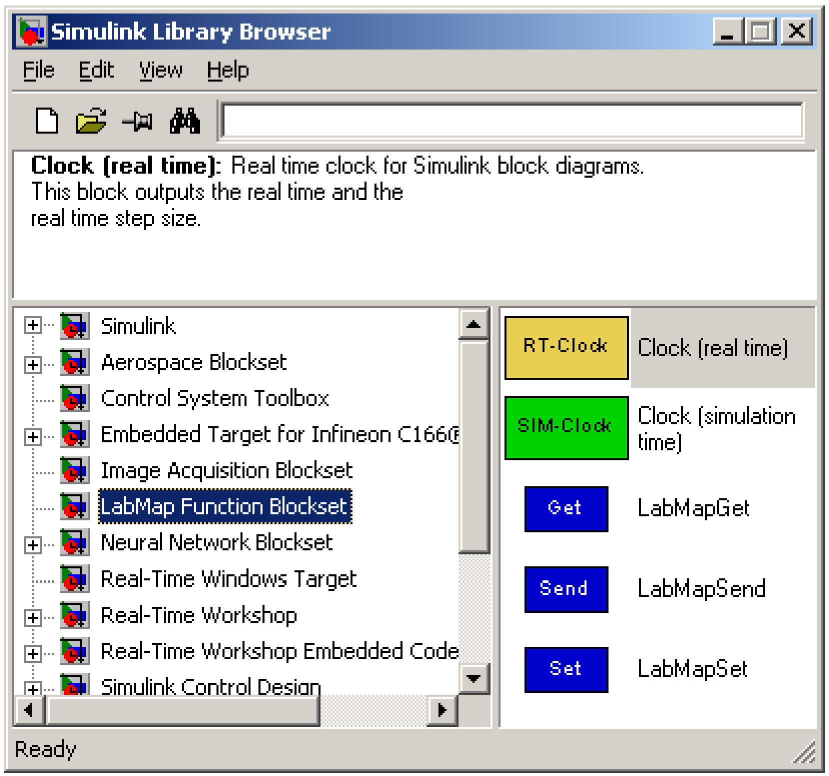
- **Blackboard**, asynchronous notifications upon
  value / time stamp set events
  error events
  leaving / entering value bounds

Network protocol

- **Appears as a bus**
  - peer-to-peer connections abstracted away
  - remote variables are accessed through local proxy variables
- **Transparent data and time synchronization**
  - measurement units are checked and converted as necessary
  - time stamps are converted between unsynchronized partitions
- **Transparent remote control**
  - I/O requests executed on proxies are marshaled to remote hardware
  - Notification services consider it as a part of I/O process
- **Access control**
  - shared variables
  - exclusive access variables

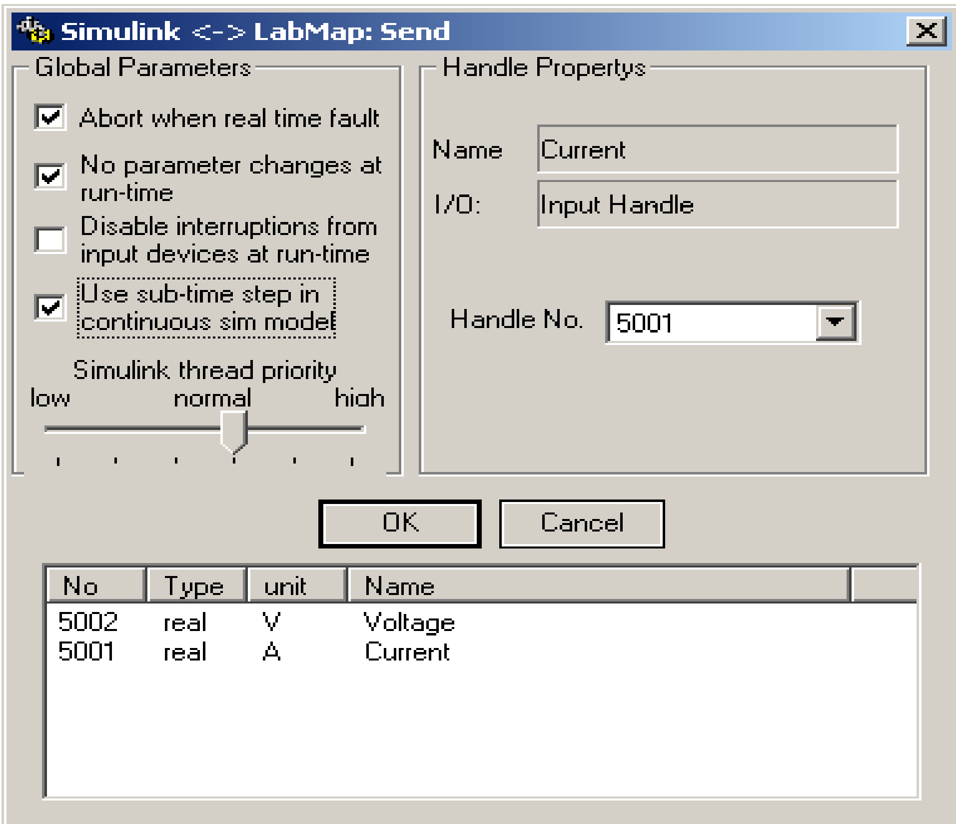
LabMap/Simulink Toolbox

The toolbox provides an access the software bus in a MatLab/Simulink model that runs in normal simulation mode



In the Simulink Library Browser the LabMap Function Blockset appears after installation of the LabMap toolbox for MatLab

Properties Dialog



Name: the name of the LabMap register

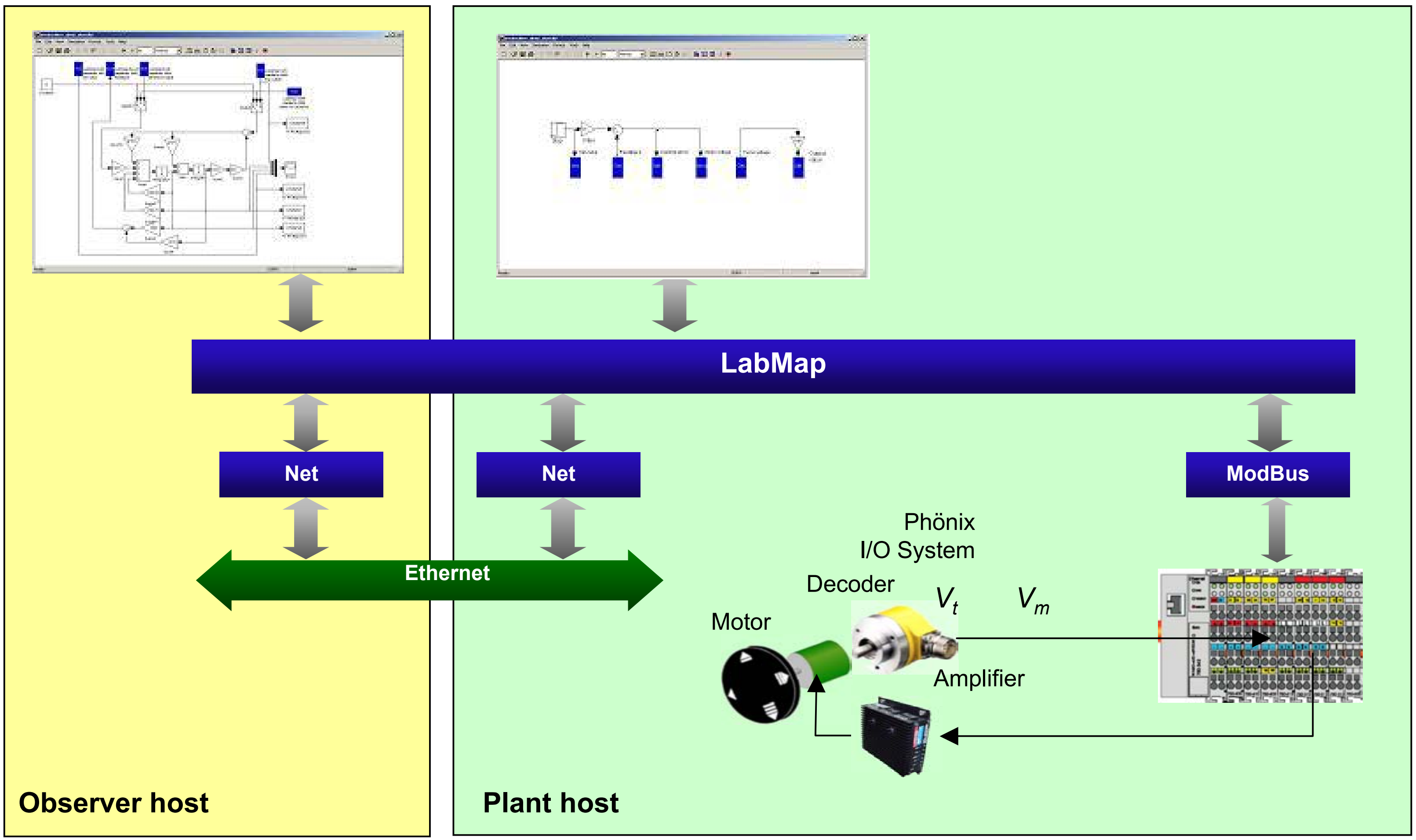
I/O: the direction of the LabMap register

Handle No.: the LabMap register number

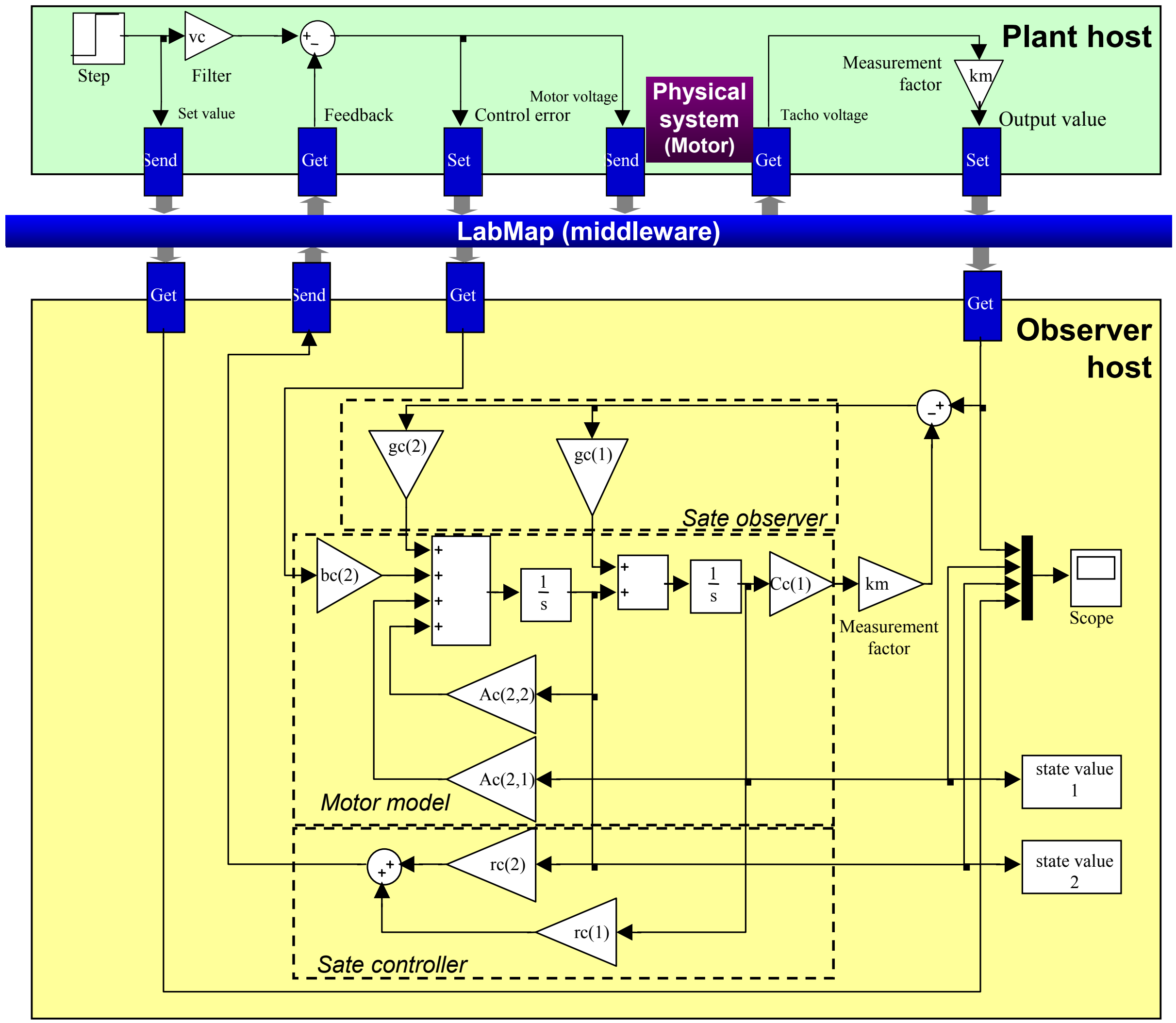
Sub-time steps in continuous simulation model

Simulink thread priority

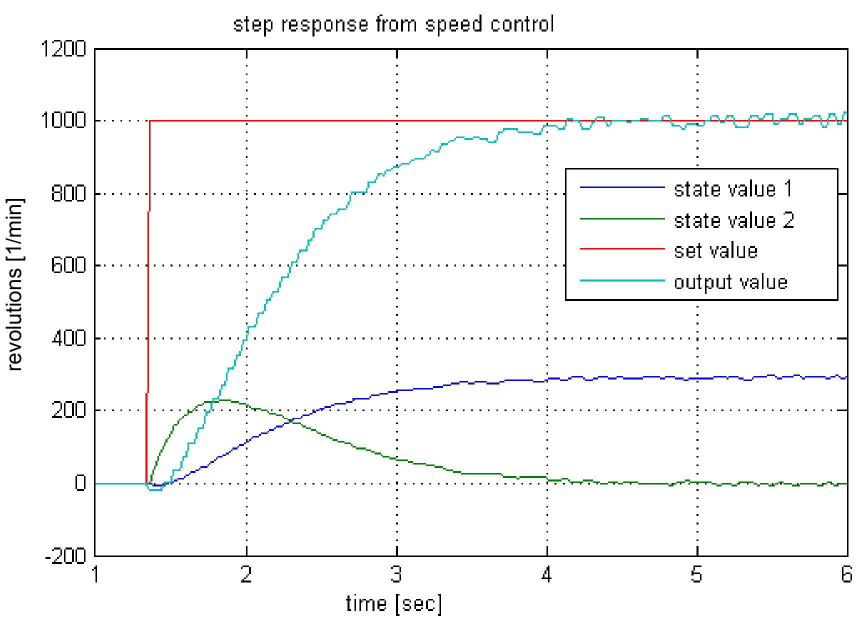
System setup



Distributed Simulink model



Step response




```
ObserverCalc.m
%calculation of state space controller and
%luenberger observer
%the system identificatin was carried out
%by the system identification
%software toolbox IDICON
num = [3.2637]     %result from system
                   %identification
den = [1 10.862 11.205]    %frequency domain
Ac=[0 1; -den(3) -den(2)]; %state spaces
                           %discription
bc=[0;num];
Cc=[1 0];

km=den(3)/num              %measurment factor
cm=km*Cc;
p=[-10 -20];               %pole placement
                           %observer
gc=(acker(Ac',Cc',p))';    %state observer
                           %gc=[19.138;
                           %-19.082]
prc = [-2 -2.5];           %pole placement
                           %controller
rc=acker(Ac,bc,prc);       %state controller
                           %rc=[-1.9013
                           %-1.9493]
vc=inv(cm*inv(bc*rc-Ac)*bc);%filter vc=0.44622
```

Summary

A middleware technology appears feasible in control applications for accessing remote hardware components and distributing control over the network. It also provides:

- high degree of flexibility in heterogeneous distributed systems
- reliability, openness, scalability, userfriendliness
- few installation efforts
- easy integration into existing systems