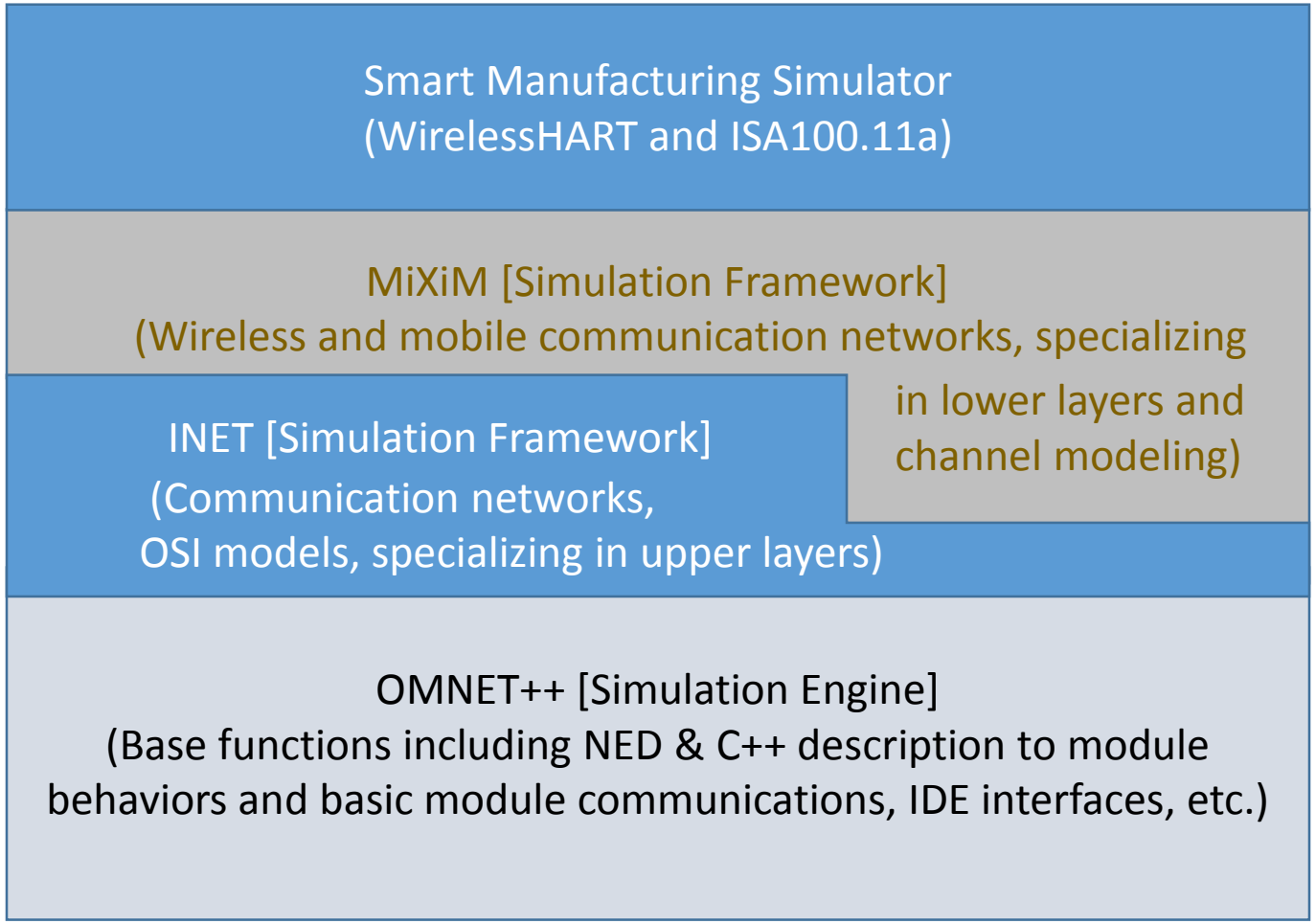
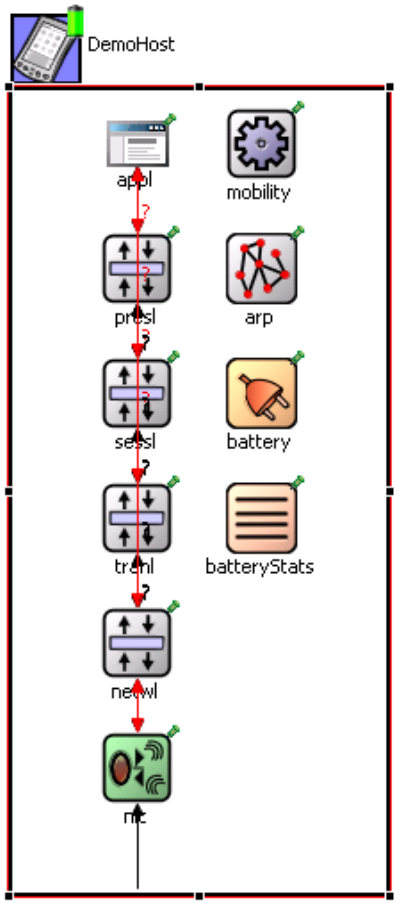
Smart Manufacturing Simulator Overview

- Open source and strong library support
- OSI model and WirelessHART/ISA100.11a features
- Flexible scenario (coexistence)
- Easy to maintain
- Powerful animation and analysis


Smart Manufacturing Simulator
(WirelessHART and ISA100.11a)
MiXiM [Simulation Framework]
(Wireless and mobile communication networks, specializing in lower layers and channel modeling)
INET [Simulation Framework]
(Communication networks, OSI models, specializing in upper layers)
OMNET++ [Simulation Engine]
(Base functions including NED & C++ description to module behaviors and basic module communications, IDE interfaces, etc.)

Protocol Stack Models



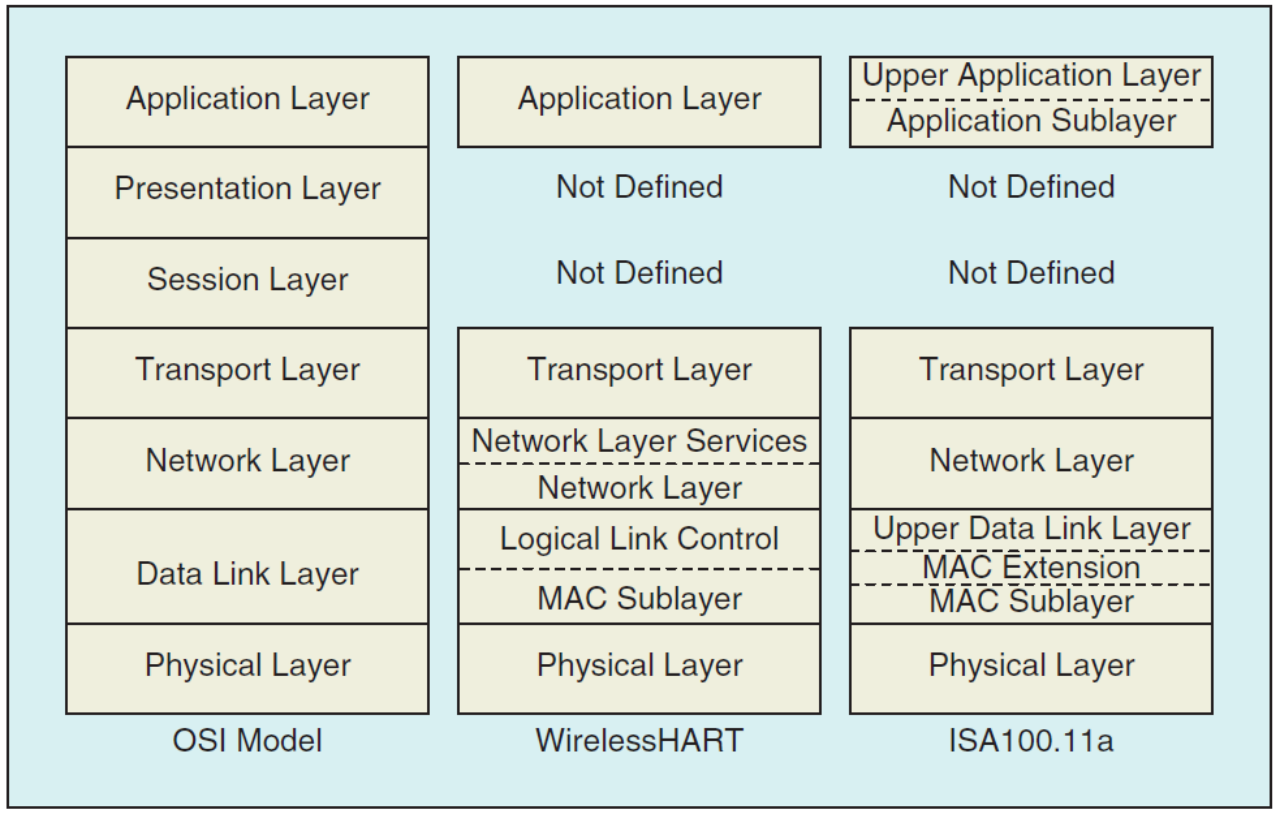
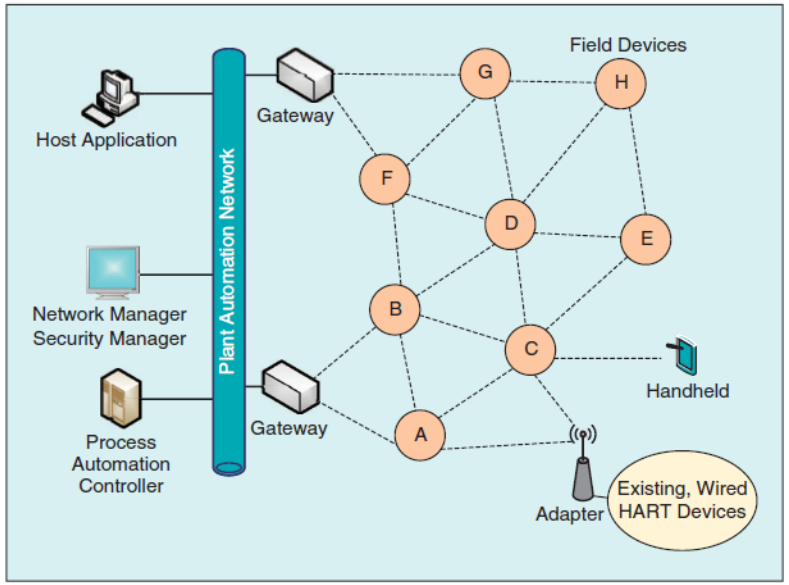
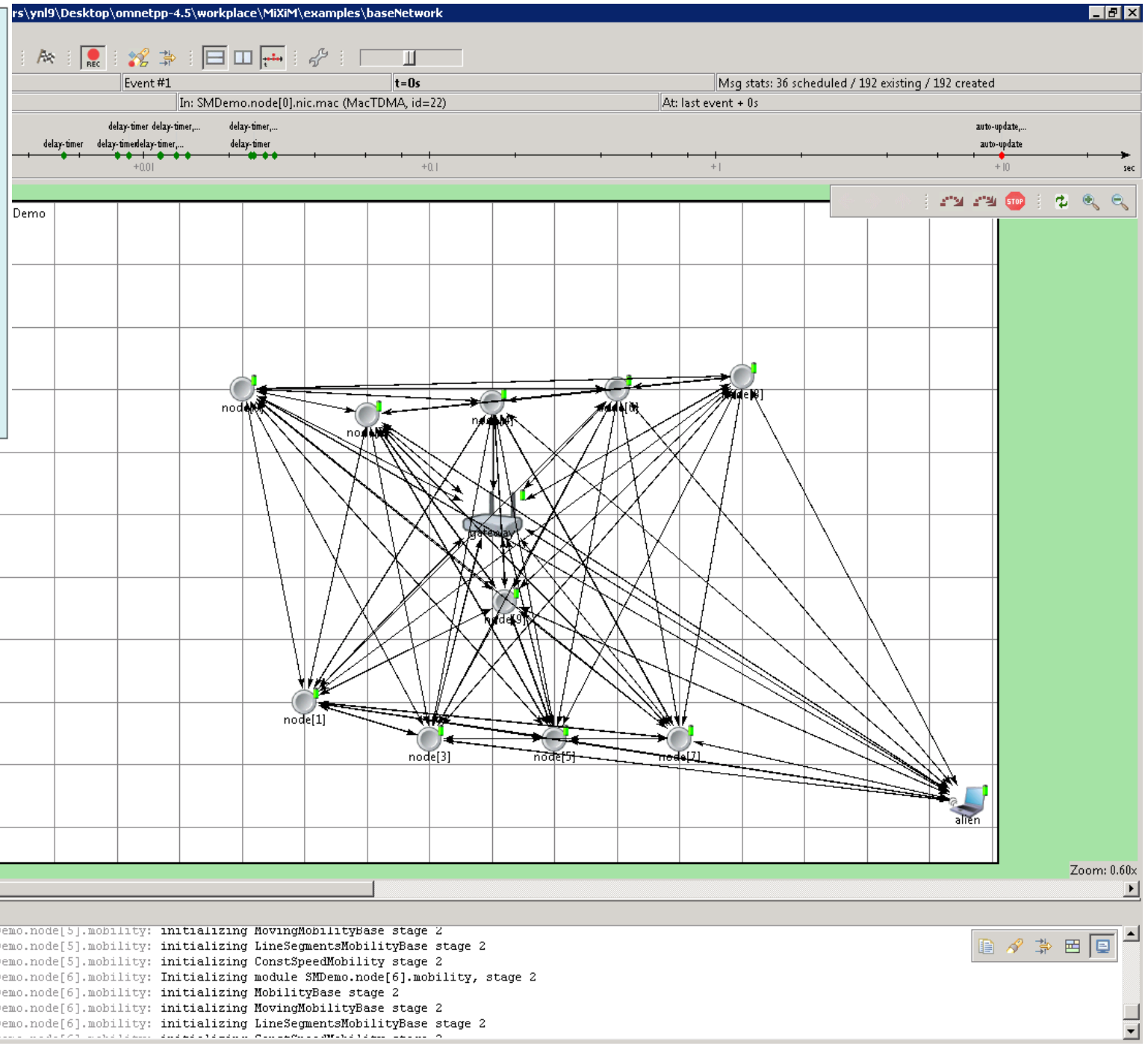
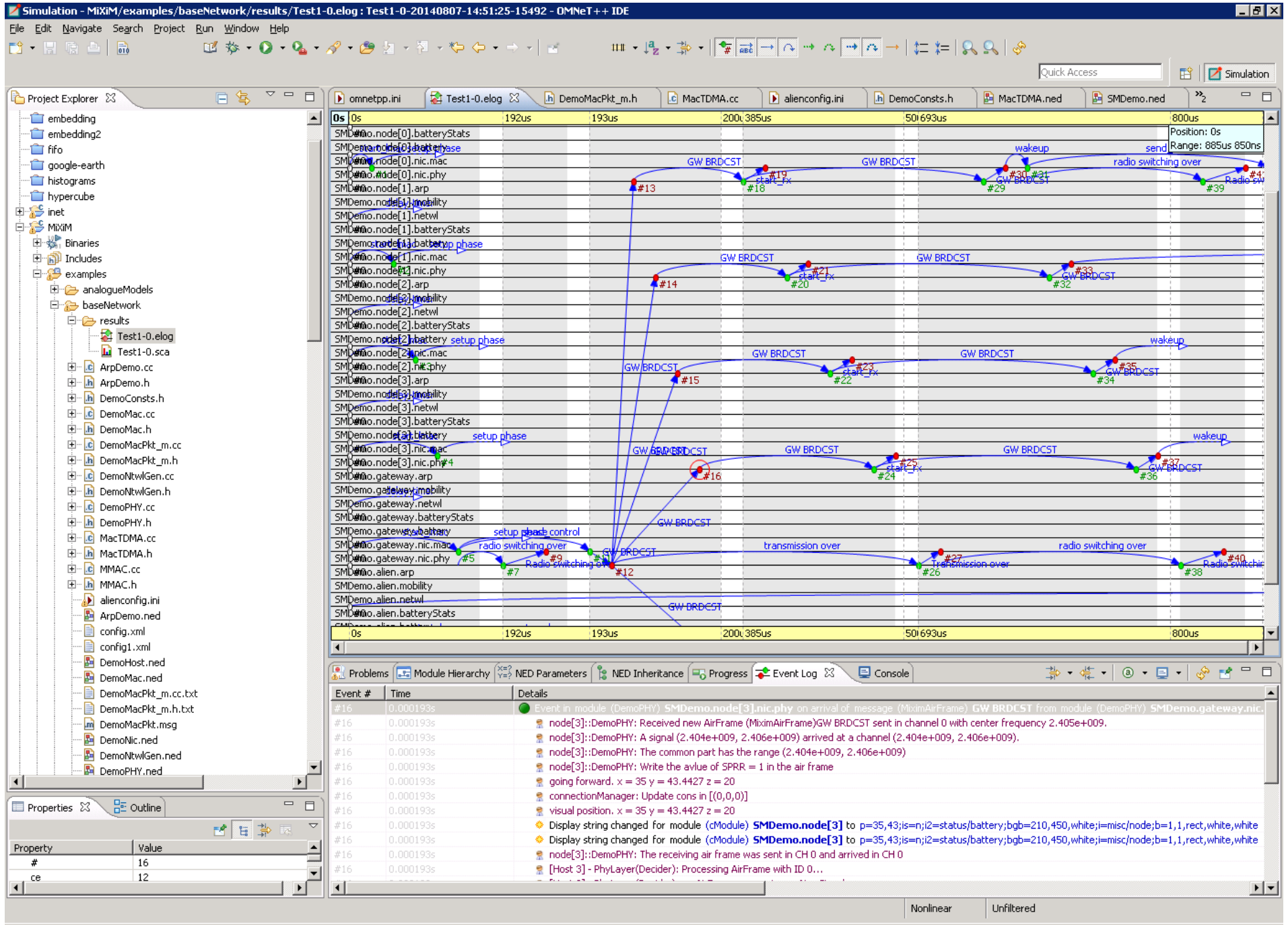


FIGURE 4 – The WirelessHART and ISA100.11a stack models.

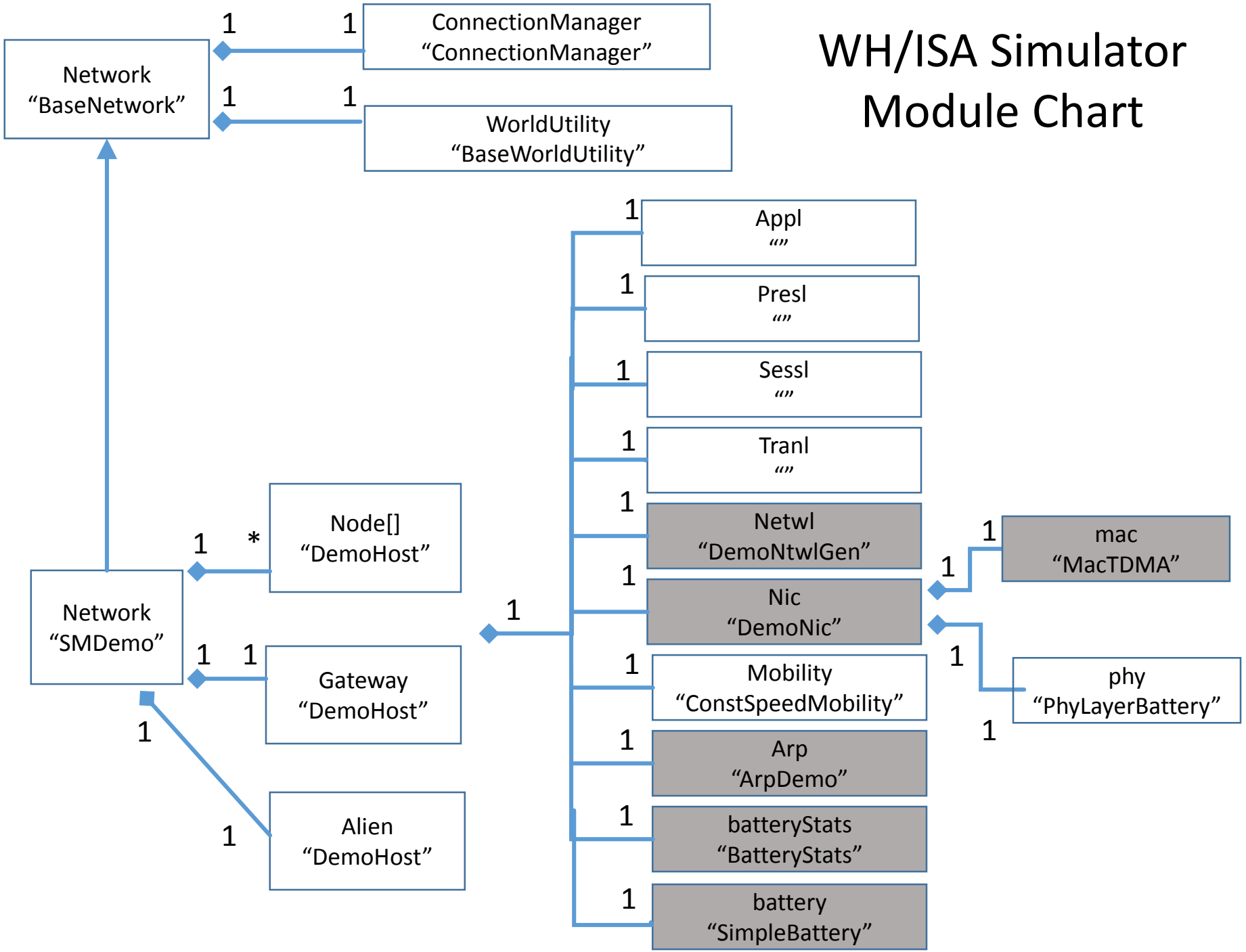
Both adopt the IEEE 802.15.4 DSSS radio for coexistence in ISM bands


Field Devices
Host Application
Gateway
G
H
F
D
E
B
C
Handheld
Network Manager
Security Manager
Plant Automation Network
Gateway
A
Process
Automation
Controller
Adapter
Existing, Wired
HART Devices


rs\ynl9\Desktop\omnetpp-4.5\workplace\MiXiM\examples\baseNetwork
Event #1
t=0s
Msg stats: 36 scheduled / 192 existing / 192 created
In: SMDemo.node[0].nic.mac (MacTDMA, id=22)
At: last event + 0s
delay-timer
auto-update
sec
Demo
node[1]
node[3]
node[5]
node[7]
alien
Zoom: 0.60x
(SMDemo) SMDemo
Fields
Contents (20)
Class
Name
cPar playgroundSizeX
cPar playgroundSizeY
cPar playgroundSizeZ
cPar cmType
cPar wuType
cPar numNodes
ConnectionManag connectionManager
BaseWorldUtility world
DemoHost node[0]
DemoHost node[1]
DemoHost node[2]
DemoHost node[3]
DemoHost node[4]
DemoHost node[5]
DemoHost node[6]
DemoHost node[7]
DemoHost node[8]
DemoHost node[9]
DemoHost gateway
DemoHost alien
SMDemo.node[5].mobility: initializing MovingMobilityBase stage 2
SMDemo.node[5].mobility: initializing LineSegmentsMobilityBase stage 2
SMDemo.node[5].mobility: initializing ConstSpeedMobility stage 2
SMDemo.node[6].mobility: Initializing module SMDemo.node[6].mobility, stage 2
SMDemo.node[6].mobility: initializing MobilityBase stage 2
SMDemo.node[6].mobility: initializing MovingMobilityBase stage 2
SMDemo.node[6].mobility: initializing LineSegmentsMobilityBase stage 2


Simulation - MiXiM/examples/baseNetwork/results/Test1-0.elog : Test1-0-20140807-14:51:25-15492 - OMNeT++ IDE
File Edit Navigate Search Project Run Window Help
Quick Access
Simulation
Project Explorer
embedding
embedding2
fifo
google-earth
histograms
hypercube
inet
MiXiM
Binaries
Includes
examples
analogueModels
baseNetwork
results
Test1-0.elog
Test1-0.sca
ArpDemo.cc
ArpDemo.h
DemoConsts.h
DemoMac.cc
DemoMac.h
DemoMacPkt_m.cc
DemoMacPkt_m.h
DemoNtwlGen.cc
DemoNtwlGen.h
DemoPHY.cc
DemoPHY.h
MacTDMA.cc
MacTDMA.h
MMAC.cc
MMAC.h
alienconfig.ini
ArpDemo.ned
config.xml
config1.xml
DemoHost.ned
DemoMac.ned
DemoMacPkt_m.cc.txt
DemoMacPkt_m.h.txt
DemoMacPkt.msg
DemoNic.ned
DemoNtwlGen.ned
DemoPHY.ned
omnetpp.ini
Test1-0.elog
DemoMacPkt_m.h
MacTDMA.cc
alienconfig.ini
DemoConsts.h
MacTDMA.ned
SMDemo.ned
0s
192us
193us
385us
693us
800us
Position: 0s
Range: 885us 850ns
SMDemo.node[0].batteryStats
SMDemo.node[0].nic.mac
SMDemo.node[0].nic.phy
SMDemo.node[1].arp
SMDemo.node[1].mobility
SMDemo.node[1].netwl
SMDemo.node[1].batteryStats
SMDemo.node[1].nic.mac
SMDemo.node[1].nic.phy
SMDemo.node[2].arp
SMDemo.node[2].mobility
SMDemo.node[2].netwl
SMDemo.node[2].batteryStats
SMDemo.node[2].nic.mac
SMDemo.node[2].nic.phy
SMDemo.node[3].arp
SMDemo.node[3].mobility
SMDemo.node[3].netwl
SMDemo.node[3].batteryStats
SMDemo.node[3].nic.mac
SMDemo.node[3].nic.phy
SMDemo.gateway.arp
SMDemo.gateway.mobility
SMDemo.gateway.netwl
SMDemo.gateway.batteryStats
SMDemo.gateway.nic.mac
SMDemo.gateway.nic.phy
SMDemo.alien.arp
SMDemo.alien.mobility
SMDemo.alien.netwl
SMDemo.alien.batteryStats
GW BRDCST
wakeup
send
radio switching over
setup phase
setup phase control
transmission over
start_fx
Problems
Module Hierarchy
NED Parameters
NED Inheritance
Progress
Event Log
Console
Event #
Time
Details
Properties
Outline
Property
Value
Nonlinear
Unfiltered

WH/ISA Simulator Module Chart



Coexistence

- Network may contain more than one type of wireless devices in a simulation, e.g., IEEE 802.11 and IEEE 802.15.4

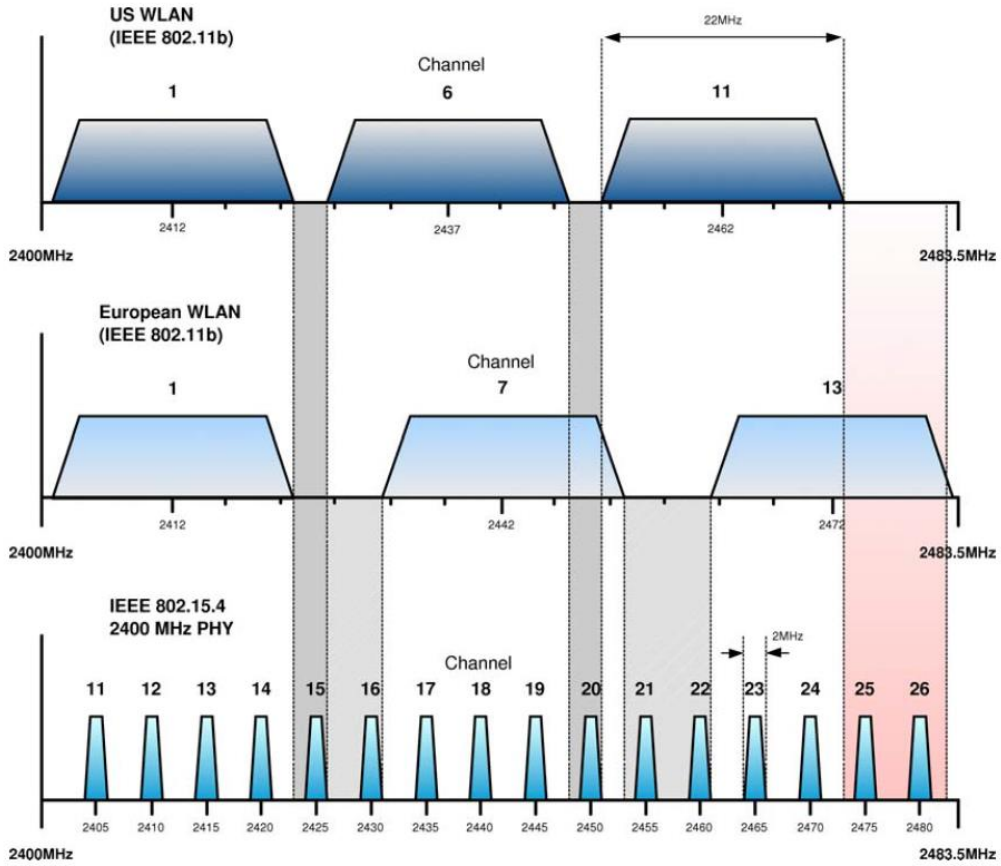
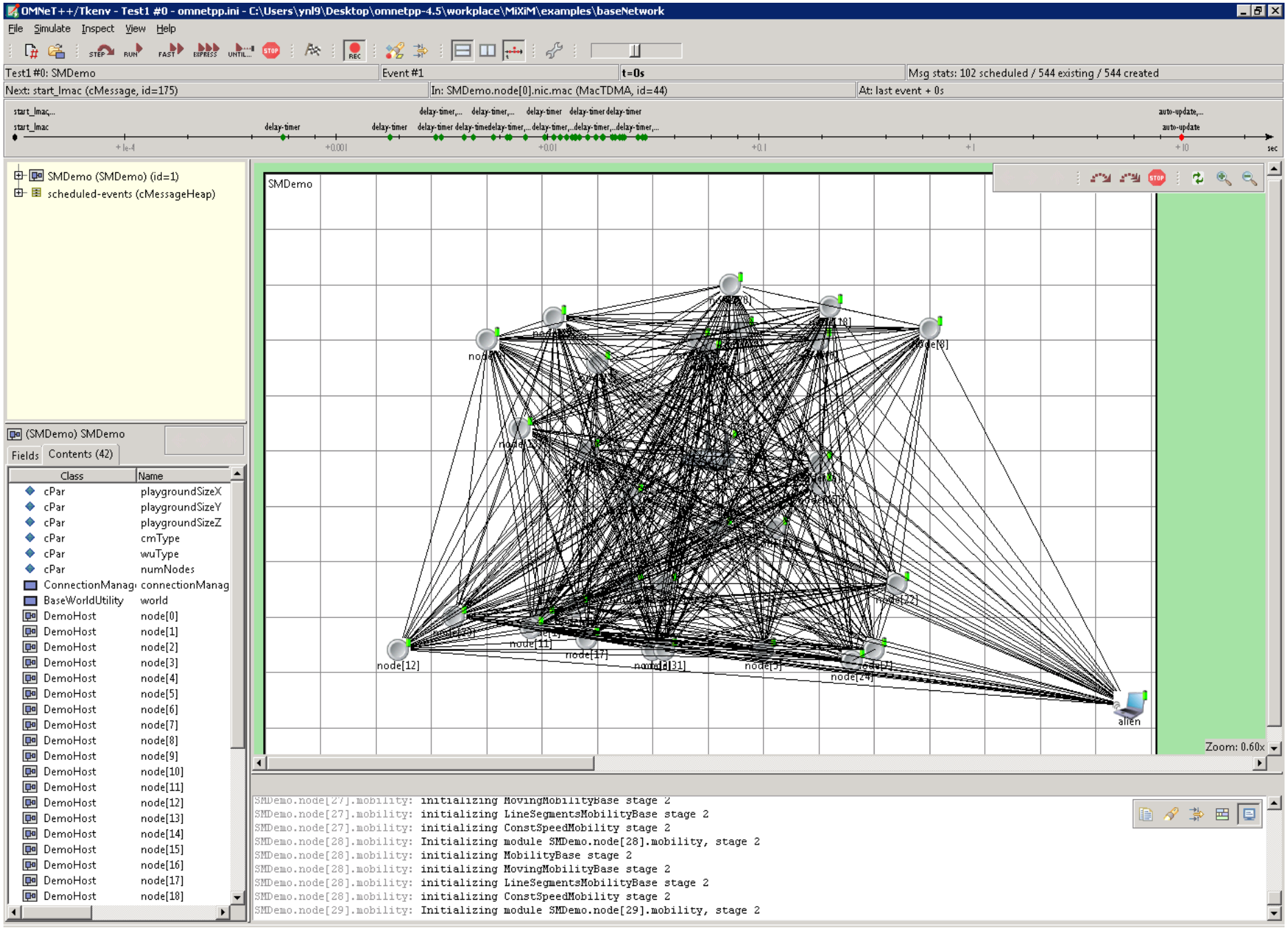


Figure 4: LR-WPAN vs Non-Overlapping WLAN Channel Allocations


OMNeT++/Tkenv - Test1 #0 - omnetpp.ini - C:\Users\ynl9\Desktop\omnetpp-4.5\workplace\MiXiM\examples\baseNetwork
File Simulate Inspect View Help
Test1 #0: SMDemo
Event #1
t=0s
Msg stats: 102 scheduled / 544 existing / 544 created
Next: start_lmac (cMessage, id=175)
In: SMDemo.node[0].nic.mac (MacTDMA, id=44)
At: last event + 0s
SMDemo (SMDemo) (id=1)
scheduled-events (cMessageHeap)
(SMDemo) SMDemo
Fields
Contents (42)
Class
Name
cPar playgroundSizeX
cPar playgroundSizeY
cPar playgroundSizeZ
cPar cmType
cPar wuType
cPar numNodes
ConnectionManag connectionManag
BaseWorldUtility world
DemoHost node[0]
DemoHost node[1]
DemoHost node[2]
DemoHost node[3]
DemoHost node[4]
DemoHost node[5]
DemoHost node[6]
DemoHost node[7]
DemoHost node[8]
DemoHost node[9]
DemoHost node[10]
DemoHost node[11]
DemoHost node[12]
DemoHost node[13]
DemoHost node[14]
DemoHost node[15]
DemoHost node[16]
DemoHost node[17]
DemoHost node[18]
SMDemo
node[12]
alien
Zoom: 0.60x
SMDemo.node[27].mobility: initializing MovingMobilityBase stage 2
SMDemo.node[27].mobility: initializing LineSegmentsMobilityBase stage 2
SMDemo.node[27].mobility: initializing ConstSpeedMobility stage 2
SMDemo.node[28].mobility: Initializing module SMDemo.node[28].mobility, stage 2
SMDemo.node[28].mobility: initializing MobilityBase stage 2
SMDemo.node[28].mobility: initializing MovingMobilityBase stage 2
SMDemo.node[28].mobility: initializing LineSegmentsMobilityBase stage 2
SMDemo.node[28].mobility: initializing ConstSpeedMobility stage 2
SMDemo.node[29].mobility: Initializing module SMDemo.node[29].mobility, stage 2

Simulator Features

- Star topology (1 access point + up to 64 field nodes)
- IEEE 802.15.4 radio based WirelessHART/ISA100.11a protocol stack
- Support broadcast/unicast traffic by addresses
- Multi-channel access (16 channels in 2.4 GHz ISM band, 2 MHz bandwidth with 5 MHz separation)
- Online network setup and time-frequency scheduling
- Parameter settings by TI CC2420 chip data sheet
- Coexistence with other ISM band devices (programmable operation parameters, e.g., center frequency, bandwidth, transmission power and interference period)

Node Architecture

- All nodes in the simulator follows the 7-layer OSI model (7 layer modules)
- Additional function modules (battery, mobility, etc.)
- Different roles, e.g., AP, field node and interferer (alien), determined by different settings (e.g., services, addresses, FSMs, and tx powers)
- Focus on the lower three layers (NW, MAC and PHY)
- Node behaviors in each layer is regulated by one OMNET++ simple module and represented by functions in C++ classes
- Upper layer module design is waiting for more information from the specification of field practice (TBD)

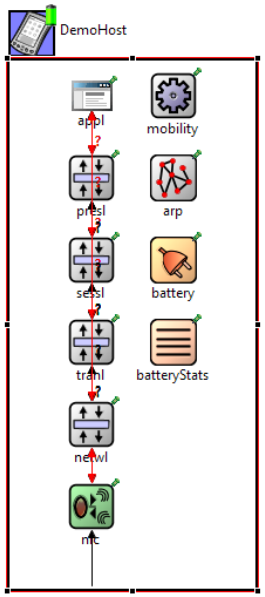


Figure. Node layer modules and function modules in the simulator