Smart Home Case Study

This file supplements the proposed approach and provides the arithmetic functions of the Smart Home Case Study generated from the corresponding GRL/feature model by jUCM-Nav, and the corresponding optimization model for IBM CPLEX' constraint programming optimizer.

1.1 Python/SymPy Code Generated using jUCMNav

Listing A.1 displays the arithmetic functions of the Smart Home Management System generated from its GRL and feature models by jUCMNav.

Listing 1.1: Python/SymPy code generated in SmartHome.py

```
from MathTo import *
from sympy import *
import sys
import os

# Creating a folder using Model name
ModelName= 'UrnspeC'
if not os.path.exists(ModelName):
    os.makedirs(ModelName)
os.chdir(ModelName)

# Initalize all the variables
Minimize_consumptioN = Symbol('Minimize_consumptioN')
Manage_energY = Symbol('Manage_energY')
Manage_applianceS = Symbol('Manage_applianceS')
Wind_turbines = Symbol('Wind_turbines')
Off_heateR = Symbol('Off_heateR')
On_heateR = Symbol('On_heateR')
Off_dish_washeR = Symbol('Off_dish_washeR')
On_dish_washeR = Symbol('On_dish_washeR')
Maximize_energy_productioN = Symbol('Maximize_energy_productioN')
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Wind_speeD = Symbol('Wind_speeD')
Electricity_pricE = Symbol('Electricity_pricE')
LighT = Symbol('LighT')
Smart_griD = Symbol('Smart_griD')
Manage_homE = Symbol('Manage_homE')
Solar_paneL = Symbol('Solar_paneL')
Provided_serviceS = Symbol('Provided_serviceS')
WifI = Symbol('WifI')
InterneT = Symbol('InterneT')
Response_timE = Symbol('Response_timE')
Open_windowS = Symbol('Open_windowS')
On_air_conditioneR = Symbol('On_air_conditioneR')
Off_air_conditioneR = Symbol('Off_air_conditioneR')
Close_windowS = Symbol('Close_windowS')
On_water_heateR = Symbol('On_water_heateR')
Off_water_heateR = Symbol('Off_water_heateR')
On_air_ventilatoR = Symbol('On_air_ventilatoR')
Off_air_ventilatoR = Symbol('Off_air_ventilatoR')
Suitable_weatheR = Symbol('Suitable_weatheR')
Maximize_privacY = Symbol('Maximize_privacY')
Maximize_comforT = Symbol('Maximize_comforT')
Normalize_inside_temperaturE = Symbol('Normalize_inside_temperaturE')
Heating_timE = Symbol('Heating_timE')
Heating_water_timE = Symbol('Heating_water_timE')
Cooling_timE = Symbol('Cooling_timE')
Remote_coolinG = Symbol('Remote_coolinG')
Remote_heatinG = Symbol('Remote_heatinG')
Remote_water_heatinG = Symbol('Remote_water_heatinG')
FulL = Symbol('FulL')
Air_conditioner_schedulE = Symbol('Air_conditioner_schedulE')
Water_heater_schedulE = Symbol('Water_heater_schedulE')
Heater_schedulE = Symbol('Heater_schedulE')
High_temperaturE = Symbol('High_temperaturE')
NormalizE = Symbol('NormalizE')
Smoke_detectioN = Symbol('Smoke_detectioN')
Operate_related_taskS = Symbol('Operate_related_taskS')
Refresh_inside_aiR = Symbol('Refresh_inside_aiR')
Low_temperaturE = Symbol('Low_temperaturE')
User_permissioN = Symbol('User_permissioN')
Air_conditioner_remote_accesS = Symbol('Air_conditioner_remote_accesS')
Water_heater_remote_accesS = Symbol('Water_heater_remote_accesS')
Heater_remote_accesS = Symbol('Heater_remote_accesS')
Motion_sensorS = Symbol('Motion_sensorS')
Light_sensorS = Symbol('Light_sensorS')
Smoke_detectoR = Symbol('Smoke_detectoR')
Smart_security_camerA = Symbol('Smart_security_camerA')
Wind_sensorS = Symbol('Wind_sensorS')
No_suspicious_behaviour_detecteD = Symbol('
    No_suspicious_behaviour_detecteD')
Monitor_the_environmenT = Symbol('Monitor_the_environmenT')
Set_thermostatE = Symbol('Set_thermostatE')
Infrared_sensoR = Symbol('Infrared_sensoR')
Cyber_attack_detectioN = Symbol('Cyber_attack_detectioN')
Maximize_securitY = Symbol('Maximize_securitY')
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Temperature_settinG = Symbol('Temperature_settinG')
Temperature_remote_accesS = Symbol('Temperature_remote_accesS')
Detect_suspicious_behaviouR = Symbol('Detect_suspicious_behaviouR')
Learning_techniquE = Symbol('Learning_techniquE')
Cooling_habitS = Symbol('Cooling_habitS')
Heating_habitS = Symbol('Heating_habitS')
FirE = Symbol('FirE')
Enable_water_heater_accesS = Symbol('Enable_water_heater_accesS')
Enable_air_conditioner_accesS = Symbol('Enable_air_conditioner_accesS')
Enable_heater_accesS = Symbol('Enable_heater_accesS')
Enable_heater_schedulE = Symbol('Enable_heater_schedulE')
Enable_air_conditioner_schedulE = Symbol('Enable_air_conditioner_schedulE
    ')
Enable_water_heater_schedulE = Symbol('Enable_water_heater_schedulE')
Enable_temperature_accesS = Symbol('Enable_temperature_accesS')
Minimize_consumptioN = Max(0.0 , Min(100.0 , (25*Open_windowS+50*InterneT
    +25*Water_heater_schedulE+25*Heater_schedulE+25*
    Air_conditioner_schedulE+75*Learning_techniquE+-25*On_air_ventilatoR)
    / 100.0))
Wind_turbines = Max(0.0 , Min(100.0 , (100*Wind_speeD) / 100.0))
Manage_energY = Max(Wind_turbines,Max(Solar_paneL,Smart_griD))
Manage_applianceS = Max(Max(On_water_heateR,On_dish_washeR),Max(
    Off_water_heateR,Off_dish_washeR))
On_heateR = Min(Low_temperaturE,Max(0.0 , Min(100.0 , (-100*
    Smoke_detectioN+Max(Remote_heatinG,Max(Heating_habitS,Heating_timE))
    *100.0) / 100.0)))
On_dish_washeR = Min(Electricity_pricE , FulL)
Maximize_energy_productioN = Max(0.0 , Min(100.0 , (100*Wind_turbines
    +100*Solar_paneL) / 100.0))
Manage_homE = Min(Min(Min(Min(Max(Smart_security_camerA,Max(
    Motion_sensorS,Cyber_attack_detectioN)),Smoke_detectoR),Min(Min(
    Wind_sensorS,Light_sensorS),Min(Infrared_sensoR,Max(
    Temperature_settinG , Temperature_remote_accesS)))),Max(Max(
    On_air_conditioneR , On_heateR) , Max(Max(Max(Open_windowS ,
    On_air_ventilatoR),Off_heateR),Max(Off_air_ventilatoR,Max(
    Off_air_conditioneR,Close_windowS))))),Min(Max(Wind_turbines,Max(
    Solar_paneL,Smart_griD)),Min(Max(Max(On_water_heateR,On_dish_washeR),
    Max(Off_water_heateR,Off_dish_washeR)),Max(Max(WifI,Max(
    Heater_schedulE,InterneT)),Max(Max(Learning_techniquE,
    Air_conditioner_remote_accesS),Max(Max(Water_heater_schedulE,
    Air_conditioner_schedulE),Max(Heater_remote_accesS,
    Water_heater_remote_accesS)))))))
Solar_paneL = Max(0.0 , Min(100.0 , (100*LighT) / 100.0))
Provided_serviceS = Max(Max(WifI,Max(Heater_schedulE,InterneT)),Max(Max(
    Learning_techniquE,Air_conditioner_remote_accesS),Max(Max(
    Water_heater_schedulE,Air_conditioner_schedulE),Max(
    Heater_remote_accesS,Water_heater_remote_accesS))))
InterneT = Min(No_suspicious_behaviour_detecteD , Response_timE)
Open_windowS = Max(0.0 , Min(100.0 , (100*FirE+Min(Suitable_weatheR,Min(
    No_suspicious_behaviour_detecteD,User_permissioN))*100.0) / 100.0))
On_air_conditioneR = Min(High_temperaturE,Max(0.0 , Min(100.0 , (-100*
    Smoke_detectioN+Max(Remote_coolinG,Max(Cooling_habitS,Cooling_timE))
    *100.0) / 100.0)))
On_water_heateR = Max(Remote_water_heatinG , Heating_water_timE)
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On_air_ventilatoR = Max(0.0 , Min(100.0 , (100*Smoke_detectioN) / 100.0))
Maximize_privacY = Max(0.0 , Min(100.0 , (-25*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*Air_conditioner_schedulE
    +25*On_air_ventilatoR+-25*Open_windowS) / 100.0))
Maximize_comforT = Max(0.0 , Min(100.0 , (50*InterneT+25*
    Air_conditioner_schedulE+25*Heater_schedulE+25*Water_heater_schedulE
    +-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*Temperature_settinG+75*Max
    (Smart_security_camerA ,Max(Motion_sensorS ,Cyber_attack_detectioN))) /
    100.0))+25*Temperature_remote_accesS+75*Learning_techniquE) / 100.0))
Normalize_inside_temperaturE = Max(Max(On_air_conditioneR , On_heateR) ,
    Max(Max(Max(Open_windowS , On_air_ventilatoR) ,Off_heateR) ,Max(
    Off_air_ventilatoR ,Max(Off_air_conditioneR ,Close_windowS))))
Heating_timE = Min(Heater_schedulE ,Piecewise((100 , Heating_timE>=100.0)
    , (abs( (Heating_timE - 99.99) / 0.010000000000005116) * 50 + 50 ,
    (99.99<=Heating_timE)&(Heating_timE<100.0)) , (-abs( (Heating_timE -
    99.99) / -99.99) * 50 + 50 , (0.0<Heating_timE)&(Heating_timE<99.99))
    , (0 , True)))
Heating_water_timE = Min(Water_heater_schedulE ,Piecewise((100 ,
    Heating_water_timE>=100.0) , (abs( (Heating_water_timE - 99.99) /
    0.010000000000005116) * 50 + 50 , (99.99<=Heating_water_timE)&(
    Heating_water_timE<100.0)) , (-abs( (Heating_water_timE - 99.99) /
    -99.99) * 50 + 50 , (0.0<Heating_water_timE)&(Heating_water_timE
    <99.99)) , (0 , True)))
Cooling_timE = Min(Air_conditioner_schedulE ,Piecewise((100 , Cooling_timE
    >=100.0) , (abs( (Cooling_timE - 99.99) / 0.010000000000005116) * 50 +
     50 , (99.99<=Cooling_timE)&(Cooling_timE<100.0)) , (-abs( (
    Cooling_timE - 99.99) / -99.99) * 50 + 50 , (0.0<Cooling_timE)&(
    Cooling_timE<99.99)) , (0 , True)))
Remote_coolinG = Min(Air_conditioner_remote_accesS ,Piecewise((100 ,
    Remote_coolinG>=100.0) , (abs( (Remote_coolinG - 99.99) /
    0.010000000000005116) * 50 + 50 , (99.99<=Remote_coolinG)&(
    Remote_coolinG<100.0)) , (-abs( (Remote_coolinG - 99.99) / -99.99) *
    50 + 50 , (0.0<Remote_coolinG)&(Remote_coolinG<99.99)) , (0 , True)))
Remote_heatinG = Min(Heater_remote_accesS ,Piecewise((100 , Remote_heatinG
    >=100.0) , (abs( (Remote_heatinG - 99.9) / 0.09999999999999432) * 50 +
     50 , (99.9<=Remote_heatinG)&(Remote_heatinG<100.0)) , (-abs( (
    Remote_heatinG - 99.9) / -99.9) * 50 + 50 , (0.0<Remote_heatinG)&(
    Remote_heatinG<99.9)) , (0 , True)))
Remote_water_heatinG = Min(Water_heater_remote_accesS ,Piecewise((100 ,
    Remote_water_heatinG>=100.0) , (abs( (Remote_water_heatinG - 99.99) /
    0.010000000000005116) * 50 + 50 , (99.99<=Remote_water_heatinG)&(
    Remote_water_heatinG<100.0)) , (-abs( (Remote_water_heatinG - 99.99) /
     -99.99) * 50 + 50 , (0.0<Remote_water_heatinG)&(Remote_water_heatinG
    <99.99)) , (0 , True)))
FulL = Min(Infrared_sensoR ,Piecewise((100 , FulL>=100.0) , (abs( (FulL -
    99.99) / 0.010000000000005116) * 50 + 50 , (99.99<=FulL)&(FulL<100.0))
     , (-abs( (FulL - 99.99) / -99.99) * 50 + 50 , (0.0<FulL)&(FulL<99.99)
    ) , (0 , True)))
Air_conditioner_schedulE = Max(0.0 , Min(100.0 , (100*
    Enable_air_conditioner_schedulE) / 100.0))
Water_heater_schedulE = Max(0.0 , Min(100.0 , (100*
    Enable_water_heater_schedulE) / 100.0))
Heater_schedulE = Max(0.0 , Min(100.0 , (100*Enable_heater_schedulE) /
    100.0))
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High_temperaturE = Min(Max(Temperature_settinG ,
    Temperature_remote_accesS),Piecewise((100 , High_temperaturE<=10.0) ,
    (abs( (High_temperaturE - 10.99) / 0.9900000000000002) * 50 + 50 ,
    (10.0<High_temperaturE)&(High_temperaturE<=10.99)) , (-abs( (
    High_temperaturE - 10.99) / -0.009999999999999787) * 50 + 50 , (10.99<
    High_temperaturE)&(High_temperaturE<11.0)) , (0 , True)))
NormalizE = Max(On_air_conditioneR , On_heateR)
Smoke_detectioN = Min(Smoke_detectoR,Piecewise((100 , Smoke_detectioN
    >=100.0) , (abs( (Smoke_detectioN - 99.99) / 0.010000000000005116) *
    50 + 50 , (99.99<=Smoke_detectioN)&(Smoke_detectioN<100.0)) , (-abs( (
    Smoke_detectioN - 99.99) / -99.99) * 50 + 50 , (0.0<Smoke_detectioN)&(
    Smoke_detectioN<99.99)) , (0 , True)))
Operate_related_taskS = Max(Max(Max(Open_windowS , On_air_ventilatoR),
    Off_heateR),Max(Off_air_ventilatoR,Max(Off_air_conditioneR,
    Close_windowS)))
Refresh_inside_aiR = Max(Open_windowS , On_air_ventilatoR)
Low_temperaturE = Min(Max(Temperature_settinG , Temperature_remote_accesS
    ),Piecewise((100 , Low_temperaturE>=27.0) , (abs( (Low_temperaturE -
    26.99) / 0.010000000000001563) * 50 + 50 , (26.99<=Low_temperaturE)&(
    Low_temperaturE<27.0)) , (-abs( (Low_temperaturE - 26.99) /
    -0.00999999999999801) * 50 + 50 , (26.98<Low_temperaturE)&(
    Low_temperaturE<26.99)) , (0 , True)))
Air_conditioner_remote_accesS = Max(0.0 , Min(100.0 , (100*
    Enable_air_conditioner_accesS) / 100.0))
Water_heater_remote_accesS = Max(0.0 , Min(100.0 , (100*
    Enable_water_heater_accesS) / 100.0))
Heater_remote_accesS = Max(0.0 , Min(100.0 , (100*Enable_heater_accesS) /
     100.0))
No_suspicious_behaviour_detecteD = Piecewise((100 ,
    No_suspicious_behaviour_detecteD) , (0 , True))
Monitor_the_environmenT = Min(Min(Max(Smart_security_camerA,Max(
    Motion_sensorS,Cyber_attack_detectioN)),Smoke_detectoR),Min(Min(
    Wind_sensorS,Light_sensorS),Min(Infrared_sensoR,Max(
    Temperature_settinG , Temperature_remote_accesS))))
Set_thermostatE = Max(Temperature_settinG , Temperature_remote_accesS)
Maximize_securitY = Max(0.0 , Min(100.0 , (-25*InterneT+25*
    Temperature_settinG+75*Max(Smart_security_camerA,Max(Motion_sensorS,
    Cyber_attack_detectioN))) / 100.0))
Temperature_remote_accesS = Max(0.0 , Min(100.0 , (100*
    Enable_temperature_accesS) / 100.0))
Detect_suspicious_behaviouR = Max(Smart_security_camerA,Max(
    Motion_sensorS,Cyber_attack_detectioN))
Cooling_habitS = Min(Learning_techniquE,Piecewise((100 , Cooling_habitS
    <=0.0) , (abs( (Cooling_habitS - 10.0) / 10.0) * 50 + 50 , (0.0<
    Cooling_habitS)&(Cooling_habitS<=10.0)) , (-abs( (Cooling_habitS -
    10.0) / -10.0) * 50 + 50 , (10.0<Cooling_habitS)&(Cooling_habitS<20.0)
    ) , (0 , True)))
Heating_habitS = Min(Learning_techniquE,Piecewise((100 , Heating_habitS
    <=0.0) , (abs( (Heating_habitS - 10.0) / 10.0) * 50 + 50 , (0.0<
    Heating_habitS)&(Heating_habitS<=10.0)) , (-abs( (Heating_habitS -
    10.0) / -10.0) * 50 + 50 , (10.0<Heating_habitS)&(Heating_habitS<20.0)
    ) , (0 , True)))
# Actor function
InhabitantS = (Max(0.0 , Min(100.0 , (100*Wind_turbines+100*Solar_paneL)
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    / 100.0))*15+Max(0.0 , Min(100.0 , (25*Open_windowS+50*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*Air_conditioner_schedulE
    +75*Learning_techniquE+-25*On_air_ventilatoR) / 100.0))*15+Max(0.0 ,
    Min(100.0 , (-25*InterneT+25*Water_heater_schedulE+25*Heater_schedulE
    +25*Air_conditioner_schedulE+25*On_air_ventilatoR+-25*Open_windowS) /
    100.0))*25+Max(0.0 , Min(100.0 , (50*InterneT+25*
    Air_conditioner_schedulE+25*Heater_schedulE+25*Water_heater_schedulE
    +-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*Temperature_settinG+75*Max
    (Smart_security_camerA,Max(Motion_sensorS,Cyber_attack_detectioN))) /
    100.0))+25*Temperature_remote_accesS+75*Learning_techniquE) / 100.0))
    *15+Max(0.0 , Min(100.0 , (-25*InterneT+25*Water_heater_schedulE+25*
    Heater_schedulE+25*Air_conditioner_schedulE+25*On_air_ventilatoR+-25*
    Open_windowS) / 100.0))*25+Max(0.0 , Min(100.0 , (50*InterneT+25*
    Air_conditioner_schedulE+25*Heater_schedulE+25*Water_heater_schedulE
    +-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*Temperature_settinG+75*Max
    (Smart_security_camerA,Max(Motion_sensorS,Cyber_attack_detectioN))) /
    100.0))+25*Temperature_remote_accesS+75*Learning_techniquE) / 100.0))
    *15+Max(0.0 , Min(100.0 , (25*Open_windowS+50*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*Air_conditioner_schedulE
    +75*Learning_techniquE+-25*On_air_ventilatoR) / 100.0))*15+Max(0.0 ,
    Min(100.0 , (-25*InterneT+25*Temperature_settinG+75*Max(
    Smart_security_camerA,Max(Motion_sensorS,Cyber_attack_detectioN))) /
    100.0))*30+Max(0.0 , Min(100.0 , (-25*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*Air_conditioner_schedulE
    +25*On_air_ventilatoR+-25*Open_windowS) / 100.0))*25+Max(0.0 , Min
    (100.0 , (50*InterneT+25*Air_conditioner_schedulE+25*Heater_schedulE
    +25*Water_heater_schedulE+-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*
    Temperature_settinG+75*Max(Smart_security_camerA,Max(Motion_sensorS,
    Cyber_attack_detectioN))) / 100.0))+25*Temperature_remote_accesS+75*
    Learning_techniquE) / 100.0))*15+Max(0.0 , Min(100.0 , (25*
    Open_windowS+50*InterneT+25*Water_heater_schedulE+25*Heater_schedulE
    +25*Air_conditioner_schedulE+75*Learning_techniquE+-25*
    On_air_ventilatoR) / 100.0))*15+Max(0.0 , Min(100.0 , (-25*InterneT
    +25*Temperature_settinG+75*Max(Smart_security_camerA,Max(
    Motion_sensorS,Cyber_attack_detectioN))) / 100.0))*30) / 240
# Actor function
SmarthomesysteM = (Min(Min(Min(Min(Max(Smart_security_camerA,Max(
    Motion_sensorS,Cyber_attack_detectioN)),Smoke_detectoR),Min(Min(
    Wind_sensorS,Light_sensorS),Min(Infrared_sensoR,Max(
    Temperature_settinG , Temperature_remote_accesS)))),Max(Max(
    On_air_conditioneR , On_heateR) , Max(Max(Max(Open_windowS ,
    On_air_ventilatoR),Off_heateR),Max(Off_air_ventilatoR,Max(
    Off_air_conditioneR,Close_windowS))))),Min(Max(Wind_turbines,Max(
    Solar_paneL,Smart_griD)),Min(Max(Max(On_water_heateR,On_dish_washeR),
    Max(Off_water_heateR,Off_dish_washeR)),Max(Max(WifI,Max(
    Heater_schedulE,InterneT)),Max(Max(Learning_techniquE,
    Air_conditioner_remote_accesS),Max(Max(Water_heater_schedulE,
    Air_conditioner_schedulE),Max(Heater_remote_accesS,
    Water_heater_remote_accesS)))))))*100) / 100
# The function of Model
UrnspeC = ((Max(0.0 , Min(100.0 , (100*Wind_turbines+100*Solar_paneL) /
    100.0))*15+Max(0.0 , Min(100.0 , (25*Open_windowS+50*InterneT+25*
    Water_heater_schedulE+25* Heater_schedulE+25*Air_conditioner_schedulE
    +75*Learning_techniquE+-25*On_air_ventilatoR) / 100.0))*15+ Max(0.0 ,
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    Min(100.0 , (-25*InterneT+25*Water_heater_schedulE+ 25*Heater_schedulE
    + 25*Air_conditioner_schedulE+25*On_air_ventilatoR+-25*Open_windowS) /
     100.0))*25+
Max(0.0 , Min(100.0 , (50*InterneT+25*Air_conditioner_schedulE+25*
    Heater_schedulE+25*Water_heater_schedulE+-25*Max(0.0 , Min(100.0 ,
    (-25*InterneT+25*Temperature_settinG+ 75*Max(Smart_security_camerA ,Max
    (Motion_sensorS ,Cyber_attack_detectioN))) / 100.0))+25*
    Temperature_remote_accesS+ 75*Learning_techniquE) / 100.0))*15+Max(0.0
     , Min(100.0 , (-25*InterneT+25*Water_heater_schedulE+ 25*
    Heater_schedulE+25*Air_conditioner_schedulE+25*On_air_ventilatoR+-25*
    Open_windowS) / 100.0))*25+Max(0.0 , Min(100.0 , (50*InterneT+25*
    Air_conditioner_schedulE+25*Heater_schedulE+25*Water_heater_schedulE
    +-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*Temperature_settinG+ 75*
    Max(Smart_security_camerA ,Max(Motion_sensorS ,Cyber_attack_detectioN)))
     / 100.0))+25*Temperature_remote_accesS+ 75*Learning_techniquE) /
    100.0))*15+Max(0.0 , Min(100.0 , (25*Open_windowS+50*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*Air_conditioner_schedulE
    +75*Learning_techniquE+-25*On_air_ventilatoR) / 100.0))*15+Max(0.0 ,
    Min(100.0 , (-25*InterneT+25*Temperature_settinG+75* Max(
    Smart_security_camerA ,Max(Motion_sensorS ,Cyber_attack_detectioN))) /
    100.0))*30+Max(0.0 , Min(100.0 , (-25*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*Air_conditioner_schedulE
    +25*On_air_ventilatoR+-25*Open_windowS) / 100.0))*25+Max(0.0 , Min
    (100.0 , (50*InterneT+25*Air_conditioner_schedulE+25*Heater_schedulE
    +25*Water_heater_schedulE+
-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*Temperature_settinG+75*Max(
    Smart_security_camerA ,Max(Motion_sensorS ,Cyber_attack_detectioN))) /
    100.0))+25*Temperature_remote_accesS+75*Learning_techniquE) / 100.0))
    *15+Max(0.0 , Min(100.0 , (25*Open_windowS+50*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*Air_conditioner_schedulE
    +75*Learning_techniquE+-25*On_air_ventilatoR) / 100.0))*15+Max(0.0 ,
    Min(100.0 , (-25*InterneT+25*Temperature_settinG+75* Max(
    Smart_security_camerA ,Max(Motion_sensorS , Cyber_attack_detectioN))) /
    100.0))*30) / 240*50+(Min(Min(Min(Min(Max(Smart_security_camerA , Max(
    Motion_sensorS ,Cyber_attack_detectioN)),Smoke_detectoR), Min(Min(
    Wind_sensorS ,Light_sensorS),Min(Infrared_sensoR ,Max(
    Temperature_settinG , Temperature_remote_accesS)))),Max(Max(
    On_air_conditioneR , On_heateR) , Max(Max(Max(Open_windowS ,
    On_air_ventilatoR) ,Off_heateR), Max(Off_air_ventilatoR , Max(
    Off_air_conditioneR , Close_windowS))))),
Min(Max(Wind_turbines ,Max(Solar_paneL ,Smart_griD)), Min(Max(Max(
    On_water_heateR ,On_dish_washeR) ,Max(Off_water_heateR , Off_dish_washeR)
    ), Max(Max(WifI ,Max(Heater_schedulE ,InterneT)), Max(Max(
    Learning_techniquE , Air_conditioner_remote_accesS), Max(Max(
    Water_heater_schedulE , Air_conditioner_schedulE), Max(
    Heater_remote_accesS , Water_heater_remote_accesS )))))) *100) /
    100*50) / 100

GRLDiagramName = 'Manage_homE'

# Variable list
List = ['LighT','Motion_sensorS','Off_dish_washeR','Heating_water_timE','
    Learning_techniquE','Cooling_timE','Enable_heater_schedulE','
    Off_air_ventilatoR','Temperature_settinG','Low_temperaturE','
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    Cooling_habitS','Response_timE','Enable_water_heater_schedulE','
    User_permissioN','Suitable_weatheR','Enable_air_conditioner_schedulE',
    'On_heateR','Heating_habitS','Smart_griD','Wind_speeD','Wind_sensorS',
    'Remote_water_heatinG','Electricity_pricE','On_air_conditioneR','WifI'
    ,'Remote_coolinG','Off_air_conditioneR','High_temperaturE','
    Enable_air_conditioner_accesS','Heating_timE','Off_water_heateR','
    Enable_heater_accesS','No_suspicious_behaviour_detecteD','
    Enable_temperature_accesS','FulL','Cyber_attack_detectioN','FirE','
    Close_windowS','Smoke_detectoR','Light_sensorS','Smart_security_camerA
    ','Smoke_detectioN','Infrared_sensoR','Off_heateR','Remote_heatinG','
    Enable_water_heater_accesS']
LANG = []
langList = ['python','c','c++','java","javascript","matlab','r']
def allPrint():
    List = ['Wind_turbines','Off_dish_washeR','
        Air_conditioner_remote_accesS','Smart_security_camerA','
        Motion_sensorS','Cyber_attack_detectioN','Temperature_settinG','
        Solar_paneL','Open_windowS','Water_heater_schedulE','
        Heater_schedulE','Air_conditioner_schedulE','Learning_techniquE','
        Temperature_remote_accesS','On_air_ventilatoR','On_heateR','
        InterneT','Water_heater_schedulE','Heater_schedulE','
        Air_conditioner_schedulE','Heater_remote_accesS','
        Water_heater_remote_accesS','Smart_griD','On_water_heateR','
        On_dish_washeR','Off_water_heateR','Off_dish_washeR','
        Smoke_detectoR','Wind_sensorS','Light_sensorS','Infrared_sensoR','
        Open_windowS' , 'On_air_ventilatoR','Off_heateR','
        Off_air_ventilatoR','Off_air_conditioneR','Close_windowS','
        On_air_conditioneR','WifI']
    Translate(''((Max(0.0 , Min(100.0 , (100*Wind_turbines+100*Solar_paneL
        ) / 100.0))*15+Max(0.0 , Min(100.0 , (25*Open_windowS+50*InterneT
        +25*Water_heater_schedulE+25*Heater_schedulE+25*
        Air_conditioner_schedulE+75*Learning_techniquE+-25*
        On_air_ventilatoR) / 100.0))*15+Max(0.0 , Min(100.0 , (-25*
        InterneT+25*Water_heater_schedulE+25*Heater_schedulE+25*
        Air_conditioner_schedulE+25*On_air_ventilatoR+-25*Open_windowS) /
        100.0))*25+Max(0.0 , Min(100.0 , (50*InterneT+25*
        Air_conditioner_schedulE+25*Heater_schedulE+25*
        Water_heater_schedulE+-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*
        Temperature_settinG+75*Max(Smart_security_camerA ,Max(
        Motion_sensorS ,Cyber_attack_detectioN))) / 100.0))+25*
        Temperature_remote_accesS+75*Learning_techniquE) / 100.0))*15+Max
        (0.0 , Min(100.0 , (-25*InterneT+25*Water_heater_schedulE+25*
        Heater_schedulE+25*Air_conditioner_schedulE+25*On_air_ventilatoR
        +-25*Open_windowS) / 100.0))*25+Max(0.0 , Min(100.0 , (50*InterneT
        +25*Air_conditioner_schedulE+25*Heater_schedulE+25*
        Water_heater_schedulE+-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*
        Temperature_settinG+75*Max(Smart_security_camerA ,Max(
        Motion_sensorS ,Cyber_attack_detectioN))) / 100.0))+25*
        Temperature_remote_accesS+75*Learning_techniquE) / 100.0))*15+Max
        (0.0 , Min(100.0 , (25*Open_windowS+50*InterneT+25*
        Water_heater_schedulE+25*Heater_schedulE+25*
        Air_conditioner_schedulE+75*Learning_techniquE+-25*
        On_air_ventilatoR) / 100.0))*15+
    Max(0.0 , Min(100.0 , (-25*InterneT+25*Temperature_settinG+75*Max(
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    Smart_security_camerA,Max(Motion_sensorS,Cyber_attack_detectioN)))
     / 100.0))*30+Max(0.0 , Min(100.0 , (-25*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*
    Air_conditioner_schedulE+25*On_air_ventilatoR+-25*Open_windowS) /
    100.0))*25+Max(0.0 , Min(100.0 , (50*InterneT+25*
    Air_conditioner_schedulE+25*Heater_schedulE+25*
    Water_heater_schedulE+-25*Max(0.0 , Min(100.0 , (-25*InterneT+25*
    Temperature_settinG+75*Max(Smart_security_camerA,Max(
    Motion_sensorS,Cyber_attack_detectioN))) / 100.0))+25*
    Temperature_remote_accesS+75*Learning_techniquE) / 100.0))*15+Max
    (0.0 , Min(100.0 , (25*Open_windowS+50*InterneT+25*
    Water_heater_schedulE+25*Heater_schedulE+25*
    Air_conditioner_schedulE+75*Learning_techniquE+-25*
    On_air_ventilatoR) / 100.0))*15+Max(0.0 , Min(100.0 , (-25*
    InterneT+25*Temperature_settinG+75*Max(Smart_security_camerA,Max(
    Motion_sensorS,Cyber_attack_detectioN))) / 100.0))*30) / 240*50+(
    Min(Min(Min(Min(Max(Smart_security_camerA,Max(Motion_sensorS,
    Cyber_attack_detectioN)),Smoke_detectoR),Min(Min(Wind_sensorS,
    Light_sensorS),Min(Infrared_sensoR,Max(Temperature_settinG ,
    Temperature_remote_accesS)))),Max(Max(On_air_conditioneR ,
    On_heateR) , Max(Max(Max(Open_windowS , On_air_ventilatoR),
    Off_heateR),Max(Off_air_ventilatoR,Max(Off_air_conditioneR,
    Close_windowS))))),Min(Max(Wind_turbines,Max(Solar_paneL,
    Smart_griD)),Min(Max(Max(On_water_heateR,On_dish_washeR),Max(
    Off_water_heateR,Off_dish_washeR)),Max(Max(WifI,Max(
    Heater_schedulE,InterneT)),Max(Max(Learning_techniquE,
    Air_conditioner_remote_accesS),Max(Max(Water_heater_schedulE,
    Air_conditioner_schedulE),Max(Heater_remote_accesS,
    Water_heater_remote_accesS))))))*100) / 100*50) / 100' ,
    GRLDiagramName , List , LANG,2)
# Indicators
List=['Wind_speeD']
print 'Wind_speeD'
Translate('Piecewise((100 , (Wind_speeD>=10) & (Wind_speeD<=24)),(0 ,
    True))', List[0], List, LANG,2)
List=['Electricity_pricE']
print 'Electricity_pricE'
Translate('Piecewise((100 , Electricity_pricE<=6.4) , (0 , True))',
    List[0], List, LANG,2)
List=['LighT']
print 'LighT'
Translate('Piecewise((100 , LighT),(0 , True))', List[0], List, LANG
    ,2)
List=['Response_timE']
print 'Response_timE'
Translate('Piecewise((100 , Response_timE<=2),(0 , True))', List[0],
    List, LANG,2)
List=['Suitable_weatheR']
print 'Suitable_weatheR'
Translate('Piecewise((100 ,Suitable_weatheR),(0 , True))', List[0],
    List, LANG,2)
List=['Heating_timE','Enable_heater_schedulE']
print 'Heating_timE'
Translate('Min(Max(0.0 , Min(100.0 , (100*Enable_heater_schedulE) /
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    100.0)),Piecewise((100 , Heating_timE),(0 , True)))', List[0],
    List, LANG,2)
List=['Heating_water_timE','Enable_water_heater_schedulE']
print 'Heating_water_timE'
Translate('Min(Max(0.0 , Min(100.0 , (100*
    Enable_water_heater_schedulE) / 100.0)),Piecewise((100 ,
    Heating_water_timE),(0 , True)))', List[0], List, LANG,2)
List=['Cooling_timE','Enable_air_conditioner_schedulE']
print 'Cooling_timE'
Translate('Min(Max(0.0 , Min(100.0 , (100*
    Enable_air_conditioner_schedulE) / 100.0)),Piecewise((100 ,
    Cooling_timE),(0 , True)))', List[0], List, LANG,2)
List=['Remote_coolinG','Enable_air_conditioner_accesS']
print 'Remote_coolinG'
Translate('Min(Max(0.0 , Min(100.0 , (100*
    Enable_air_conditioner_accesS) / 100.0)),Piecewise((100 ,
    Remote_coolinG),(0 , True)))', List[0], List, LANG,2)
List=['Remote_heatinG','Enable_heater_accesS']
print 'Remote_heatinG'
Translate('Min(Max(0.0 , Min(100.0 , (100*Enable_heater_accesS) /
    100.0)),Piecewise((100 , Remote_heatinG),(0 , True)))', List[0],
    List, LANG,2)
List=['Remote_water_heatinG','Enable_water_heater_accesS']
print 'Remote_water_heatinG'
Translate('Min(Max(0.0 , Min(100.0 , (100*Enable_water_heater_accesS)
     / 100.0)),Piecewise((100 , Remote_water_heatinG),(0 , True)))',
    List[0], List, LANG,2)
List=['FulL','Infrared_sensoR']
print 'FulL'
Translate('Min(Infrared_sensoR,Piecewise((100 , FulL),(0 , True)))',
    List[0], List, LANG,2)
List=['High_temperaturE','Temperature_settinG','Response_timE','
    No_suspicious_behaviour_detecteD','Enable_temperature_accesS']
print 'High_temperaturE'
#>=27
Translate('Min(Max(Temperature_settinG , Max(0.0 , Min(100.0 , (100*
    Enable_temperature_accesS) / 100.0))),100*Min(Max( floor(
    High_temperaturE/27),0),1))', List[0], List, LANG,2)
List=['Smoke_detectioN','Smoke_detectoR']
print 'Smoke_detectioN'
Translate('Min(Smoke_detectoR,Piecewise((100 , Smoke_detectioN),(0 ,
    True)))', List[0], List, LANG,2)
List=['Low_temperaturE','Temperature_settinG','Response_timE','
    No_suspicious_behaviour_detecteD','Enable_temperature_accesS']
print 'Low_temperaturE'
Translate('Min(Max(Temperature_settinG , Max(0.0 , Min(100.0 , (100*
    Enable_temperature_accesS) / 100.0))),100*Min(Max( floor(15/
    Low_temperaturE),0),1))', List[0], List, LANG,2)
List=['User_permissioN']
print 'User_permissioN'
Translate('Piecewise((100 , User_permissioN),(0 , True))', List[0],
    List, LANG,2)
List=['No_suspicious_behaviour_detecteD']
print 'No_suspicious_behaviour_detecteD'
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    Translate('Piecewise((100 , No_suspicious_behaviour_detecteD),(0 ,
        True))', List[0], List, LANG,2)
    List=['Cooling_habitS','Learning_techniquE']
    print 'Cooling_habitS'
    Translate('Min(Learning_techniquE,Piecewise((100 , Cooling_habitS),(0
         , True)))', List[0], List, LANG,2)
      List=['Heating_habitS','Learning_techniquE']
    print 'Heating_habitS'
    Translate('Min(Learning_techniquE,Piecewise((100 ,Heating_habitS),(0
        , True)))', List[0], List, LANG,2)
    List=['FirE']
    print 'FirE'
    Translate('Piecewise((100 , FirE),(0 , True))', List[0], List, LANG
        ,2)
    List=['Enable_water_heater_accesS']
    print 'Enable_water_heater_accesS'
    Translate('Piecewise((100 , Enable_water_heater_accesS),(0 , True))',
         List[0], List, LANG,2)
    List=['Enable_air_conditioner_accesS']
    print 'Enable_air_conditioner_accesS'
    Translate('Piecewise((100 , Enable_air_conditioner_accesS),(0 , True)
        )', List[0], List, LANG,2)
    List=['Enable_heater_accesS']
    print 'Enable_heater_accesS'
    Translate('Piecewise((100 , Enable_heater_accesS),(0 , True))', List
        [0], List, LANG,2)
    List=['Enable_heater_schedulE']
    print 'Enable_heater_schedulE'
    Translate('Piecewise((100 , Enable_heater_schedulE),(0 , True))',
        List[0], List, LANG,2)
    List=['Enable_air_conditioner_schedulE']
    print 'Enable_air_conditioner_schedulE'
    Translate('Piecewise((100 , Enable_air_conditioner_schedulE),(0 ,
        True))', List[0], List, LANG,2)
    List=['Enable_water_heater_schedulE']
    print 'Enable_water_heater_schedulE'
    Translate('Piecewise((100 , Enable_water_heater_schedulE),(0 , True))
        ', List[0], List, LANG,2)
    List=['Enable_temperature_accesS']
    print 'Enable_temperature_accesS'
    Translate('Piecewise((100 , Enable_temperature_accesS),(0 , True))',
        List[0], List, LANG,2)
if(len(sys.argv)==1):
  LANG = langList
  allPrint()
else:
  for i in sys.argv:
    if(sys.argv.index(i)==0):continue
    if  (i.lower() not in langList):
      LANG = langList
      break
    else:
      LANG.append(str(i.lower()))
  allPrint()
```

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#inital all the variable
Wind_turbineS= Symbol('Wind_turbineS')
Off_heateR= Symbol('Off_heateR')
On_heateR= Symbol('On_heateR')
Off_dish_washeR= Symbol('Off_dish_washeR')
On_dish_washeR= Symbol('On_dish_washeR')
Dish_washer_controlleR= Symbol('Dish_washer_controlleR')
Air_conditioner_controlleR= Symbol('Air_conditioner_controlleR')
Power_controlleR= Symbol('Power_controlleR')
SmarthomE= Symbol('SmarthomE')
Smart_griD= Symbol('Smart_griD')
Heater_controlleR= Symbol('Heater_controlleR')
Solar_paneL= Symbol('Solar_paneL')
WifI= Symbol('WifI')
InterneT= Symbol('InterneT')
Open_windowS= Symbol('Open_windowS')
On_air_conditioneR= Symbol('On_air_conditioneR')
Off_air_conditioneR= Symbol('Off_air_conditioneR')
Close_windowS= Symbol('Close_windowS')
Water_heater_controlleR= Symbol('Water_heater_controlleR')
On_water_heateR= Symbol('On_water_heateR')
Off_water_heateR= Symbol('Off_water_heateR')
Air_ventilator_controlleR= Symbol('Air_ventilator_controlleR')
On_air_ventilatoR= Symbol('On_air_ventilatoR')
Off_air_ventilatoR= Symbol('Off_air_ventilatoR')
Smart_appliances_controlleR= Symbol('Smart_appliances_controlleR')
Windows_controlleR= Symbol('Windows_controlleR')
Air_conditioner_schedulE= Symbol('Air_conditioner_schedulE')
Water_heater_schedulE= Symbol('Water_heater_schedulE')
Heater_schedulE= Symbol('Heater_schedulE')
Heater_switcH= Symbol('Heater_switcH')
Water_heater_switcH= Symbol('Water_heater_switcH')
Air_conditioner_switcH= Symbol('Air_conditioner_switcH')
Air_conditioner_remote_accesS= Symbol('Air_conditioner_remote_accesS')
Water_heater_remote_accesS= Symbol('Water_heater_remote_accesS')
Heater_remote_accesS= Symbol('Heater_remote_accesS')
SensorS= Symbol('SensorS')
Motion_sensorS= Symbol('Motion_sensorS')
Light_sensorS= Symbol('Light_sensorS')
Smoke_detectoR= Symbol('Smoke_detectoR')
Smart_security_camerA= Symbol('Smart_security_camerA')
Wind_sensorS= Symbol('Wind_sensorS')
Smart_thermostaT= Symbol('Smart_thermostaT')
Infrared_sensoR= Symbol('Infrared_sensoR')
Cyber_attack_detectioN= Symbol('Cyber_attack_detectioN')
Temperature_settinG= Symbol('Temperature_settinG')
Temperature_remote_accesS= Symbol('Temperature_remote_accesS')
Security_sensoR= Symbol('Security_sensoR')
Internet_connectioN= Symbol('Internet_connectioN')
Learning_techniquE= Symbol('Learning_techniquE')
On_heateR= Min(Min(0,On_heateR - On_air_conditioneR),(((On_heateR + Min(
    Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 ))
On_air_conditioneR= Min(Min(0,On_air_conditioneR - On_heateR),(((
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    On_air_conditioneR + Min(Close_windowS,Off_air_ventilatoR)) / 200.0 )*
     100.0 ))
Air_conditioner_remote_accesS= (((Air_conditioner_remote_accesS +
    InterneT) / 200.0 )* 100.0 )
Water_heater_remote_accesS= (((Water_heater_remote_accesS + InterneT) /
    200.0 )* 100.0 )
Heater_remote_accesS= (((Heater_remote_accesS + InterneT) / 200.0 )*
    100.0 )
Temperature_remote_accesS= (((Temperature_remote_accesS + InterneT) /
    200.0 )* 100.0 )
Dish_washer_controlleR= (Max(Off_dish_washeR,On_dish_washeR)) / Max(1,
    Off_dish_washeR + On_dish_washeR)*100.0
Air_conditioner_controlleR= Min((Max(Off_air_conditioneR,Min(Min(0,
    On_air_conditioneR - On_heateR),(((On_air_conditioneR + Min(
    Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 )))) / Max(1,
    Off_air_conditioneR + On_air_conditioneR)*100.0,Piecewise((100,Max(
    Air_conditioner_remote_accesS,Air_conditioner_schedulE)<=0),(((((
    Air_conditioner_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Air_conditioner_schedulE) / Max(1 ,Air_conditioner_remote_accesS +
    Air_conditioner_schedulE)*100.0,True)))
Power_controlleR= Min(100,(Smart_griD + Wind_turbineS + Solar_paneL) /
    Max(1 ,Smart_griD + Wind_turbineS + Solar_paneL)*100.0)
SmarthomE= Min(Min(Min(WifI,Min(100,(Smart_griD + Wind_turbineS +
    Solar_paneL) / Max(1 ,Smart_griD + Wind_turbineS + Solar_paneL)*100.0)
    ),Min(Min(Min(Wind_sensorS,Smoke_detectoR),Min(Light_sensorS,Min(Min(
    Temperature_settinG,Piecewise((100,Temperature_remote_accesS<=0),((((
    Temperature_remote_accesS + InterneT) / 200.0 )* 100.0 ) / Max(1 ,
    Temperature_remote_accesS)*100.0,True))),Min(100,(
    Smart_security_camerA + Motion_sensorS) / Max(1 ,Smart_security_camerA
     + Motion_sensorS)*100.0)))),Min(Min((Max(Close_windowS,Open_windowS))
     / Max(1,Close_windowS + Open_windowS)*100.0,(Max(Off_dish_washeR,
    On_dish_washeR)) / Max(1,Off_dish_washeR + On_dish_washeR)*100.0),Min(
    Min((Max(On_air_ventilatoR,Off_air_ventilatoR)) / Max(1,
    On_air_ventilatoR + Off_air_ventilatoR)*100.0,Min((Max(On_water_heateR
    ,Off_water_heateR)) / Max(1,On_water_heateR + Off_water_heateR)*100.0,
    Piecewise((100,Max(Water_heater_remote_accesS,Water_heater_schedulE)
    <=0),(((((Water_heater_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Water_heater_schedulE) / Max(1 ,Water_heater_remote_accesS +
    Water_heater_schedulE)*100.0,True)))),Min(Min((Max(Min(Min(0,On_heateR
     - On_air_conditioneR),(((On_heateR + Min(Close_windowS,
    Off_air_ventilatoR)) / 200.0 )* 100.0 )),Off_heateR)) / Max(1,
    On_heateR + Off_heateR)*100.0,Piecewise((100,Max(Heater_remote_accesS,
    Heater_schedulE)<=0),(((((Heater_remote_accesS + InterneT) / 200.0 )*
    100.0 ) + Heater_schedulE) / Max(1 ,Heater_remote_accesS +
    Heater_schedulE)*100.0,True))),Min((Max(Off_air_conditioneR,Min(Min(0,
    On_air_conditioneR - On_heateR),(((On_air_conditioneR + Min(
    Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 )))) / Max(1,
    Off_air_conditioneR + On_air_conditioneR)*100.0,Piecewise((100,Max(
    Air_conditioner_remote_accesS,Air_conditioner_schedulE)<=0),(((((
    Air_conditioner_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Air_conditioner_schedulE) / Max(1 ,Air_conditioner_remote_accesS +
    Air_conditioner_schedulE)*100.0,True)))))))),Piecewise((100,Max(
    Cyber_attack_detectioN,Max(Learning_techniquE,InterneT))<=0),((Min(
    Cyber_attack_detectioN,InterneT) + Learning_techniquE) / Max(1 ,Max(
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    Cyber_attack_detectioN,InterneT) + Learning_techniquE)*100.0,True)))
Heater_controlleR= Min((Max(Min(Min(0,On_heateR - On_air_conditioneR),(((
    On_heateR + Min(Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 ))
    ,Off_heateR)) / Max(1,On_heateR + Off_heateR)*100.0,Piecewise((100,Max
    (Heater_remote_accesS,Heater_schedulE)<=0),(((((Heater_remote_accesS +
     InterneT) / 200.0 )* 100.0 ) + Heater_schedulE) / Max(1 ,
    Heater_remote_accesS + Heater_schedulE)*100.0,True)))
Water_heater_controlleR= Min((Max(On_water_heateR,Off_water_heateR)) /
    Max(1,On_water_heateR + Off_water_heateR)*100.0,Piecewise((100,Max(
    Water_heater_remote_accesS,Water_heater_schedulE)<=0),(((((
    Water_heater_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Water_heater_schedulE) / Max(1 ,Water_heater_remote_accesS +
    Water_heater_schedulE)*100.0,True)))
Air_ventilator_controlleR= (Max(On_air_ventilatoR,Off_air_ventilatoR)) /
    Max(1,On_air_ventilatoR + Off_air_ventilatoR)*100.0
Smart_appliances_controlleR= Min(Min((Max(Close_windowS,Open_windowS)) /
    Max(1,Close_windowS + Open_windowS)*100.0,(Max(Off_dish_washeR,
    On_dish_washeR)) / Max(1,Off_dish_washeR + On_dish_washeR)*100.0),Min(
    Min((Max(On_air_ventilatoR,Off_air_ventilatoR)) / Max(1,
    On_air_ventilatoR + Off_air_ventilatoR)*100.0,Min((Max(On_water_heateR
    ,Off_water_heateR)) / Max(1,On_water_heateR + Off_water_heateR)*100.0,
    Piecewise((100,Max(Water_heater_remote_accesS,Water_heater_schedulE)
    <=0),(((((Water_heater_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Water_heater_schedulE) / Max(1 ,Water_heater_remote_accesS +
    Water_heater_schedulE)*100.0,True)))),Min(Min((Max(Min(Min(0,On_heateR
     - On_air_conditioneR),(((On_heateR + Min(Close_windowS,
    Off_air_ventilatoR)) / 200.0 )* 100.0 )),Off_heateR)) / Max(1,
    On_heateR + Off_heateR)*100.0,Piecewise((100,Max(Heater_remote_accesS,
    Heater_schedulE)<=0),(((((Heater_remote_accesS + InterneT) / 200.0 )*
    100.0 ) + Heater_schedulE) / Max(1 ,Heater_remote_accesS +
    Heater_schedulE)*100.0,True))),Min((Max(Off_air_conditioneR,Min(Min(0,
    On_air_conditioneR - On_heateR),(((On_air_conditioneR + Min(
    Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 )))) / Max(1,
    Off_air_conditioneR + On_air_conditioneR)*100.0,Piecewise((100,Max(
    Air_conditioner_remote_accesS,Air_conditioner_schedulE)<=0),(((((
    Air_conditioner_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Air_conditioner_schedulE) / Max(1 ,Air_conditioner_remote_accesS +
    Air_conditioner_schedulE)*100.0,True))))))
Windows_controlleR= (Max(Close_windowS,Open_windowS)) / Max(1,
    Close_windowS + Open_windowS)*100.0
Heater_switcH= (Max(Min(Min(0,On_heateR - On_air_conditioneR),(((
    On_heateR + Min(Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 ))
    ,Off_heateR)) / Max(1,On_heateR + Off_heateR)*100.0
Water_heater_switcH= (Max(On_water_heateR,Off_water_heateR)) / Max(1,
    On_water_heateR + Off_water_heateR)*100.0
Air_conditioner_switcH= (Max(Off_air_conditioneR,Min(Min(0,
    On_air_conditioneR - On_heateR),(((On_air_conditioneR + Min(
    Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 )))) / Max(1,
    Off_air_conditioneR + On_air_conditioneR)*100.0
SensorS= Min(Min(Wind_sensorS,Smoke_detectoR),Min(Light_sensorS,Min(Min(
    Temperature_settinG,Piecewise((100,Temperature_remote_accesS<=0),((((
    Temperature_remote_accesS + InterneT) / 200.0 )* 100.0 ) / Max(1 ,
    Temperature_remote_accesS)*100.0,True))),Min(100,(
    Smart_security_camerA + Motion_sensorS) / Max(1 ,Smart_security_camerA
```

```
    + Motion_sensorS)*100.0))))
Smart_thermostaT= Min(Temperature_settinG,Piecewise((100,
    Temperature_remote_accesS<=0),((((Temperature_remote_accesS + InterneT
    ) / 200.0 )* 100.0 ) / Max(1 ,Temperature_remote_accesS)*100.0,True)))
Security_sensoR= Min(100,(Smart_security_camerA + Motion_sensorS) / Max(1
    ,Smart_security_camerA + Motion_sensorS)*100.0)
Internet_connectioN= Min(Cyber_attack_detectioN,InterneT)
#The function of Model
ShsfeatureS= Min(Min(Min(WifI,Min(100,(Smart_griD + Wind_turbineS +
    Solar_paneL) / Max(1 ,Smart_griD + Wind_turbineS + Solar_paneL)*100.0)
    ),Min(Min(Min(Wind_sensorS,Smoke_detectoR),Min(Light_sensorS,Min(Min(
    Temperature_settinG,Piecewise((100,Temperature_remote_accesS<=0),((((
    Temperature_remote_accesS + InterneT) / 200.0 )* 100.0 ) / Max(1 ,
    Temperature_remote_accesS)*100.0,True))),Min(100,(
    Smart_security_camerA + Motion_sensorS) / Max(1 ,Smart_security_camerA
    + Motion_sensorS)*100.0)))),Min(Min((Max(Close_windowS,Open_windowS))
    / Max(1,Close_windowS + Open_windowS)*100.0,(Max(Off_dish_washeR,
    On_dish_washeR)) / Max(1,Off_dish_washeR + On_dish_washeR)*100.0),Min(
    Min((Max(On_air_ventilatoR,Off_air_ventilatoR)) / Max(1,
    On_air_ventilatoR + Off_air_ventilatoR)*100.0,Min((Max(On_water_heateR
    ,Off_water_heateR)) / Max(1,On_water_heateR + Off_water_heateR)*100.0,
    Piecewise((100,Max(Water_heater_remote_accesS,Water_heater_schedulE)
    <=0),(((((Water_heater_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Water_heater_schedulE) / Max(1 ,Water_heater_remote_accesS +
    Water_heater_schedulE)*100.0,True)))),Min(Min((Max(Min(Min(0,On_heateR
    - On_air_conditioneR),(((On_heateR + Min(Close_windowS,
    Off_air_ventilatoR)) / 200.0 )* 100.0 )),Off_heateR)) / Max(1,
    On_heateR + Off_heateR)*100.0,Piecewise((100,Max(Heater_remote_accesS,
    Heater_schedulE)<=0),(((((Heater_remote_accesS + InterneT) / 200.0 )*
    100.0 ) + Heater_schedulE) / Max(1 ,Heater_remote_accesS +
    Heater_schedulE)*100.0,True))),Min((Max(Off_air_conditioneR,Min(Min(0,
    On_air_conditioneR - On_heateR),(((On_air_conditioneR + Min(
    Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 )))) / Max(1,
    Off_air_conditioneR + On_air_conditioneR)*100.0,Piecewise((100,Max(
    Air_conditioner_remote_accesS,Air_conditioner_schedulE)<=0),(((((
    Air_conditioner_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
    Air_conditioner_schedulE) / Max(1 ,Air_conditioner_remote_accesS +
    Air_conditioner_schedulE)*100.0,True)))))))),Piecewise((100,Max(
    Cyber_attack_detectioN,Max(Learning_techniquE,InterneT))<=0),((Min(
    Cyber_attack_detectioN,InterneT) + Learning_techniquE) / Max(1 ,Max(
    Cyber_attack_detectioN,InterneT) + Learning_techniquE)*100.0,True)))
FMDiagramName =  'ShsfeatureS'

#variable list
List= ['Water_heater_schedulE','Motion_sensorS','Off_dish_washeR','
    Learning_techniquE','Solar_paneL','On_water_heateR','
    Off_air_ventilatoR','Temperature_settinG','Wind_turbineS','
    Heater_schedulE','Heater_remote_accesS','Water_heater_remote_accesS','
    On_heateR','On_air_ventilatoR','Smart_griD','Wind_sensorS','
    On_air_conditioneR','WifI','InterneT','Off_air_conditioneR','
    Off_water_heateR','Air_conditioner_schedulE','
    Temperature_remote_accesS','Air_conditioner_remote_accesS','
    Cyber_attack_detectioN','Close_windowS','Smoke_detectoR','
    Light_sensorS','Smart_security_camerA','Open_windowS','On_dish_washeR'
```

```
    ,'Infrared_sensoR','Off_heateR']
LANG = []
langList = ['python','c','c++','java',"javascript",'matlab','r','cp']

List= ['Water_heater_schedulE','Motion_sensorS','Off_dish_washeR','
    Learning_techniquE','Solar_paneL','On_water_heateR','
    Off_air_ventilatoR','Temperature_settinG','Wind_turbineS','
    Heater_schedulE','Heater_remote_accesS','Water_heater_remote_accesS','
    On_heateR','On_air_ventilatoR','Smart_griD','Wind_sensorS','
    On_air_conditioneR','WifI','InterneT','Off_air_conditioneR','
    Off_water_heateR','Air_conditioner_schedulE','
    Temperature_remote_accesS','Air_conditioner_remote_accesS','
    Cyber_attack_detectioN','Close_windowS','Smoke_detectoR','
    Light_sensorS','Smart_security_camerA','Open_windowS','On_dish_washeR'
    ,'Infrared_sensoR','Off_heateR']
def allPrint():
    Translate('Min(Min(Min(WifI,Min(100,(Smart_griD + Wind_turbineS +
        Solar_paneL) / Max(1 ,Smart_griD + Wind_turbineS + Solar_paneL)
        *100.0)),Min(Min(Min(Wind_sensorS,Smoke_detectoR),Min(
        Light_sensorS,Min(Min(Temperature_settinG,Piecewise((100,
        Temperature_remote_accesS<=0),((((Temperature_remote_accesS +
        InterneT) / 200.0 )* 100.0 ) / Max(1 ,Temperature_remote_accesS)
        *100.0,True))),Min(100,(Smart_security_camerA + Motion_sensorS) /
        Max(1 ,Smart_security_camerA + Motion_sensorS)*100.0)))),Min(Min((
        Max(Close_windowS,Open_windowS)) / Max(1,Close_windowS +
        Open_windowS)*100.0,(Max(Off_dish_washeR,On_dish_washeR)) / Max(1,
        Off_dish_washeR + On_dish_washeR)*100.0),Min(Min((Max(
        On_air_ventilatoR,Off_air_ventilatoR)) / Max(1,On_air_ventilatoR +
         Off_air_ventilatoR)*100.0,Min((Max(On_water_heateR,
        Off_water_heateR)) / Max(1,On_water_heateR + Off_water_heateR)
        *100.0,Piecewise((100,Max(Water_heater_remote_accesS,
        Water_heater_schedulE)<=0),(((((Water_heater_remote_accesS +
        InterneT) / 200.0 )* 100.0 ) + Water_heater_schedulE) / Max(1 ,
        Water_heater_remote_accesS + Water_heater_schedulE)*100.0,True))))
        ,Min(Min((Max(Min(Min(0,On_heateR - On_air_conditioneR),(((
        On_heateR + Min(Close_windowS,Off_air_ventilatoR)) / 200.0 )*
        100.0 )),Off_heateR)) / Max(1,On_heateR + Off_heateR)*100.0,
        Piecewise((100,Max(Heater_remote_accesS,Heater_schedulE)<=0),(((((
        Heater_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
        Heater_schedulE) / Max(1 ,Heater_remote_accesS + Heater_schedulE)
        *100.0,True))),Min((Max(Off_air_conditioneR,Min(Min(0,
        On_air_conditioneR - On_heateR),(((On_air_conditioneR + Min(
        Close_windowS,Off_air_ventilatoR)) / 200.0 )* 100.0 )))) / Max(1,
        Off_air_conditioneR + On_air_conditioneR)*100.0,Piecewise((100,Max
        (Air_conditioner_remote_accesS,Air_conditioner_schedulE)<=0),(((((
        Air_conditioner_remote_accesS + InterneT) / 200.0 )* 100.0 ) +
        Air_conditioner_schedulE) / Max(1 ,Air_conditioner_remote_accesS +
         Air_conditioner_schedulE)*100.0,True))))))),Piecewise((100,Max(
        Cyber_attack_detectioN,Max(Learning_techniquE,InterneT))<=0),((Min
        (Cyber_attack_detectioN,InterneT) + Learning_techniquE) / Max(1 ,
        Max(Cyber_attack_detectioN,InterneT) + Learning_techniquE)*100.0,
        True)))',FMDiagramName,List,LANG,2)
if(len(sys.argv)==1):
  LANG = langList
```

```
    allPrint()
else:
    for i in sys.argv:
        if(sys.argv.index(i)==0):continue
        if  (i.lower() not in langList):
            LANG = langList
            break
        else:
            LANG.append(str(i.lower()))
    allPrint()
```

1.2 Optimization Model of SHMS

Listing A.2 provides the final optimization model of the SHMS. It first defines the ancillary variables (coming from GRL indicators) and the decision variables whose values are selected by the optimizer. In addition to the feature and GRL functions (defined as "decision expressions" here, with the prefix `dexpr`), the model indicates what to maximize (the `SmartHome` GRL model) and additional constraints on some variables.

Listing 1.2: Model optimization code for the Smart Home case study, for IBM CPLEX' CP Optimizer

```
using CP;

// Ancillary variables
float Electricity_pricES=...;
int Cooling_habitSS=...;
int Cooling_timES=...;
int FirE=...;
int FulL=...;
int Heating_habitSS=...;
int Heating_timES=...;
int Heating_water_timES=...;
int LighT=...;
float TemperaturES=...;
int No_suspicious_behaviour_detecteDS=...;
int Remote_coolinGS=...;
int Remote_water_heatinGS=...;
float Response_timES=...;
int Smoke_detectioNS=...;
int Suitable_weatheR=...;
int User_permissioN=...;
float Wind_speeDS=...;
int Remote_heatinGS=...;
int Enable_water_heater_accesS=...;
int Enable_water_heater_schedulE=...;
int Enable_temperature_accesS=...;
int Enable_air_conditioner_accesS=...;
int Enable_heater_schedulE=...;
```

```
int Enable_heater_accesS=...;
int Enable_air_conditioner_schedulE=...;

// Decision variables
dvar int Learning_techniquE in 0..100;
dvar int Off_air_ventilatoR in 0..100;
dvar int Temperature_settinG in 0..100;
dvar int Wind_sensorS in 0..100;
dvar int Off_water_heateR in 0..100;
dvar int Cyber_attack_detectioN in 0..100;
dvar int Light_sensorS in 0..100;
dvar int Off_dish_washeR in 0..100;
dvar int Motion_sensorS in 0..100;
dvar int Smart_griD in 0..100;
dvar int WifI in 0..100;
dvar int Close_windowS in 0..100;
dvar int Smart_security_camerA in 0..100;
dvar int Infrared_sensoR in 0..100;
dvar int Smoke_detectoR in 0..100;
dvar int Off_heateR in 0..100;
dvar int Off_air_conditioneR in 0..100;


// Features expressions
 int Response_timE= Response_timES<=2 ? 100: 0;
dexpr int No_suspicious_behaviour_detecteD =
    No_suspicious_behaviour_detecteDS;
dexpr int InterneT = minl(No_suspicious_behaviour_detecteD ,
    Response_timE) ;
dexpr int Water_heater_remote_accesSGRL=Enable_water_heater_accesS;
dexpr int Water_heater_remote_accesS=(((Water_heater_remote_accesSGRL +
    InterneT) / 200.0 )* 100.0 )< 100? 0 :100;
dexpr int Water_heater_schedulE=Enable_water_heater_schedulE;
dexpr int Temperature_remote_accesSGRL=Enable_temperature_accesS;
dexpr int Temperature_remote_accesS=(((Temperature_remote_accesSGRL +
    InterneT) / 200.0 )* 100.0 )<100?0:100;
dexpr int Air_conditioner_remote_accesSGRL=Enable_air_conditioner_accesS;
dexpr int Air_conditioner_remote_accesS=(((
    Air_conditioner_remote_accesSGRL + InterneT) / 200.0 )* 100.0 )< 100?
    0 :100;
dexpr int Heater_schedulE=Enable_heater_schedulE;
dexpr int Heater_remote_accesSGRL=Enable_heater_accesS;
dexpr int Heater_remote_accesS=(((Heater_remote_accesSGRL + InterneT) /
    200.0 )* 100.0 )<100?0:100;
dexpr int Air_conditioner_schedulE=Enable_air_conditioner_schedulE;
dexpr int Cooling_habitS=minl(Learning_techniquE, Cooling_habitSS);
dexpr int Cooling_timE=minl(Air_conditioner_schedulE, Cooling_timES);
dexpr int Heating_habitS=minl(Learning_techniquE, Heating_habitSS);
dexpr int Heating_timE=minl(Heater_schedulE, Heating_timES);
dexpr int Heating_water_timE=minl(Water_heater_schedulE,
    Heating_water_timES);
dexpr float High_temperaturE=minl(maxl(Temperature_settinG ,
    Enable_temperature_accesS),TemperaturES>=27?100:0);
dexpr float Low_temperaturE=minl(maxl(Temperature_settinG ,
```

```
    Enable_temperature_accesS),TemperaturES<=15?100:0);
dexpr float Remote_coolinG=minl(Air_conditioner_remote_accesS,
    Remote_coolinGS);
dexpr int Remote_heatinG=minl(Heater_remote_accesS, Remote_heatinGS);
dexpr int Remote_water_heatinG=minl(Water_heater_remote_accesS,
    Remote_water_heatinGS);
dexpr float Electricity_pricE =  (Electricity_pricES <= 6.4) ? ( 100): 0;
dexpr float On_dish_washeR = minl(Electricity_pricE , FulL);
dexpr int Smoke_detectioN=minl(Smoke_detectoR, Smoke_detectioNS);
dexpr int Wind_speeD=(Wind_speeDS>=12)&&(Wind_speeDS<90)? 100:0;
dexpr int Wind_turbines = Wind_speeD;
dexpr int Solar_paneL = LighT;
dexpr int On_air_ventilatoR=Smoke_detectioN ;
dexpr float Open_windowS =  maxl(0.0 , minl(100.0 , (100*FirE+minl(
    Suitable_weatheR,minl(No_suspicious_behaviour_detecteD,User_permissioN
    ))*100.0) / 100.0)) ;
dexpr int On_water_heateR = maxl(Remote_water_heatinG ,
    Heating_water_timE) ;

// From GRL function
dexpr float On_heateRGRL = minl(Low_temperaturE,maxl(0.0 , minl(100.0 , (
    maxl(Remote_heatinG,maxl(Heating_habitS,Heating_timE))*100.0) / 100.0)
    ));
// From feature functions
dexpr float On_heateR=(((On_heateRGRL + minl(Close_windowS,
    Off_air_ventilatoR)) / 200.0 )* 100.0 )< 100? 0 :On_heateRGRL;
// From GRL function
dexpr float On_air_conditionerGRL = minl(High_temperaturE,maxl(0.0 , minl
    (100.0 , (maxl(Remote_coolinG,maxl(Cooling_habitS,Cooling_timE))
    *100.0) / 100.0))) ;
// From feature functions
dexpr float On_air_conditioneR=minl(maxl(0,On_air_conditionerGRL -
    On_heateR),(((On_air_conditionerGRL + minl(Close_windowS,
    Off_air_ventilatoR)) / 200.0 )* 100.0 ))< 100? 0 :
    On_air_conditionerGRL;

// Smart Home GRL function
dexpr float  SmartHome=(1/32)*maxl(0.0, minl(100.000000000000, 1*(
    Solar_paneL + Wind_turbines))) + (1/8)*maxl(0.0, minl
    (100.000000000000, -0.25*InterneT + 0.25*Temperature_settinG + 0.75*
    maxl(Cyber_attack_detectioN, maxl(Motion_sensorS,
    Smart_security_camerA)))) + (5/32)*maxl(0.0, minl(100.000000000000,
    0.25*(Air_conditioner_schedulE + Heater_schedulE - InterneT +
    On_air_ventilatoR - Open_windowS + Water_heater_schedulE))) + (3/32)*
    maxl(0.0, minl(100.000000000000, 0.25*Air_conditioner_schedulE + 0.25*
    Heater_schedulE + 0.5*InterneT + 0.75*Learning_techniquE - 0.25*
    On_air_ventilatoR + 0.25*Open_windowS + 0.25*Water_heater_schedulE)) +
     (3/32)*maxl(0.0, minl(100.000000000000, 0.25*Air_conditioner_schedulE
     + 0.25*Heater_schedulE + 0.5*InterneT + 0.75*Learning_techniquE +
    0.25*Temperature_remote_accesS + 0.25*Water_heater_schedulE - 0.25*
    maxl(0.0, minl(100.000000000000, -0.25*InterneT + 0.25*
    Temperature_settinG + 0.75*maxl(Cyber_attack_detectioN, maxl(
    Motion_sensorS, Smart_security_camerA)))))) + (1/2)*minl(
    Infrared_sensoR, minl(Light_sensorS, minl(Smoke_detectoR, minl(
```

```
    Wind_sensorS, minl(maxl(Temperature_remote_accesS, Temperature_settinG
    ), minl(maxl(Cyber_attack_detectioN, Motion_sensorS,
    Smart_security_camerA), minl(maxl(Smart_griD, Solar_paneL,
    Wind_turbines), minl(maxl(Off_dish_washeR, Off_water_heateR,
    On_dish_washeR, On_water_heateR), minl(maxl(Close_windowS,
    Off_air_conditioneR, Off_air_ventilatoR, Off_heateR,
    On_air_conditioneR, On_air_ventilatoR, On_heateR, Open_windowS), maxl(
    Air_conditioner_remote_accesS, maxl(Air_conditioner_schedulE, maxl(
    Heater_remote_accesS, maxl(Heater_schedulE, maxl(InterneT, maxl(
    Learning_techniquE, maxl(Water_heater_remote_accesS, maxl(
    Water_heater_schedulE, WifI))))))))))))))));
// Features model function
dexpr float FeatureModel=minl(Light_sensorS, minl(Smoke_detectoR, minl(
    Temperature_settinG, minl(WifI, minl(Wind_sensorS, minl(100.0*(
    Motion_sensorS + Smart_security_camerA)/maxl(1, Motion_sensorS +
    Smart_security_camerA), minl(100.0*maxl(Close_windowS, Open_windowS)/
    maxl(1, Close_windowS + Open_windowS), minl(100.0*maxl(
    Off_air_ventilatoR, On_air_ventilatoR)/maxl(1, Off_air_ventilatoR +
    On_air_ventilatoR), minl(100.0*maxl(Off_dish_washeR, On_dish_washeRF)/
    maxl(1, Off_dish_washeR + On_dish_washeR), minl(100.0*maxl(
    Off_water_heateR, On_water_heateR)/maxl(1, Off_water_heateR +
    On_water_heateR), minl(100.0*(Smart_griD + Solar_paneL + Wind_turbines
    )/maxl(1, Smart_griD + Solar_paneL + Wind_turbines), minl(((
    Temperature_remote_accesS <= 0) ? (
    100
)
: (
    50.0*(InterneT + Temperature_remote_accesS)/maxl(1,
        Temperature_remote_accesS)
)), minl(100.0*maxl(Off_heateR, On_heateR)/maxl(1, Off_heateR + On_heateR
    ), minl(((maxl(Cyber_attack_detectioN, maxl(InterneT,
    Learning_techniquE)) <= 0) ? (
    100
)
: (
    100.0*(Learning_techniquE + minl(Cyber_attack_detectioN, InterneT))/
        maxl(1, Learning_techniquE + maxl(Cyber_attack_detectioN, InterneT)
        )
)), minl(100.0*maxl(Off_air_conditioneR, On_air_conditioneR )/maxl(1,
    Off_air_conditioneR + On_air_conditioneR), minl(((maxl(
    Air_conditioner_remote_accesS, Air_conditioner_schedulE) <= 0) ? (
    100
)
: (
    (50.0*Air_conditioner_remote_accesS + 100.0*Air_conditioner_schedulE +
         50.0*InterneT)/maxl(1, Air_conditioner_remote_accesS +
        Air_conditioner_schedulE)
)), minl(((maxl(Heater_remote_accesS, Heater_schedulE) <= 0) ? (
    100
)
: (
    (50.0*Heater_remote_accesS + 100.0*Heater_schedulE + 50.0*InterneT)/
        maxl(1, Heater_remote_accesS + Heater_schedulE)
)), ((maxl(Water_heater_remote_accesS, Water_heater_schedulE) <= 0) ? (
```

```
    100
)
: (
    (50.0*InterneT + 50.0*Water_heater_remote_accesS + 100.0*
        Water_heater_schedulE)/maxl(1, Water_heater_remote_accesS +
        Water_heater_schedulE)
))))))))))))))))));

maximize SmartHome;

subject to {
FeatureModel==100;
decisionVar:

 Learning_techniquE==0 || Learning_techniquE==100;
 Off_air_ventilatoR==0 || Off_air_ventilatoR==100;
 Temperature_settinG==0 || Temperature_settinG==100;
 Wind_sensorS==0 || Wind_sensorS==100;
 Off_water_heateR==0 || Off_water_heateR==100;
 Cyber_attack_detectioN==0 || Cyber_attack_detectioN==100;
 Light_sensorS==0 || Light_sensorS==100;
 Off_dish_washeR==0 || Off_dish_washeR==100;
 Motion_sensorS==0 || Motion_sensorS==100;
 Smart_griD==0 || Smart_griD==100;
 WifI==0 || WifI==100;
 Close_windowS==0 || Close_windowS==100;
 Smart_security_camerA==0 || Smart_security_camerA==100;
 Infrared_sensoR==0 || Infrared_sensoR==100;
 Smoke_detectoR==0 || Smoke_detectoR==100;
 Off_heateR==0 || Off_heateR==100;
 Off_air_conditioneR==100 || Off_air_conditioneR==0 ;
}
```