Ambient Intelligence

- Building Automation for Energy Saving -

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Universidade de Brasília - Brazil

Summary

1 – AmI Concept

2 – Building Automation

3 – Wireless Automation

4 – Some LARA Projects

- Energy Saving
- Thermal Comfort
- Hybrid Climatization
- Wireless Networked Control
- User Tracking (AmI)

5 – Perspectives

Ipê Amarelo – Brazilian National Tree

Ambient Intelligence

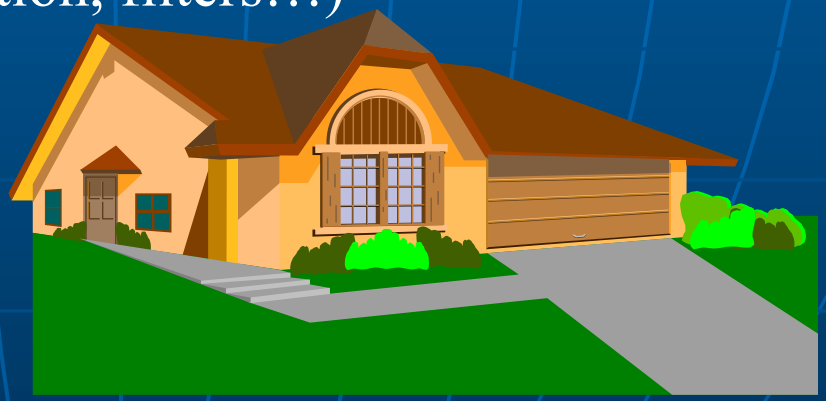
Environments that provide **services** to the users of an ambient through an *almost invisible* wireless **sensor and actuator network**

Environments that are sensitive and responsive to the **presence of people**

http://perso.limsi.fr/jps/enseignement/examsma/2004/BHATTI/

Building Automation- Objetives

- Access Control
- Fire Detection
- Comfort (Productivity)
  - temperature, humidity,… (PMV)
  - illumination,
  - waiting time for elevators, …
- Health issues
  - air quality (renovation, filters…)
  - CO_2
- Energy Saving

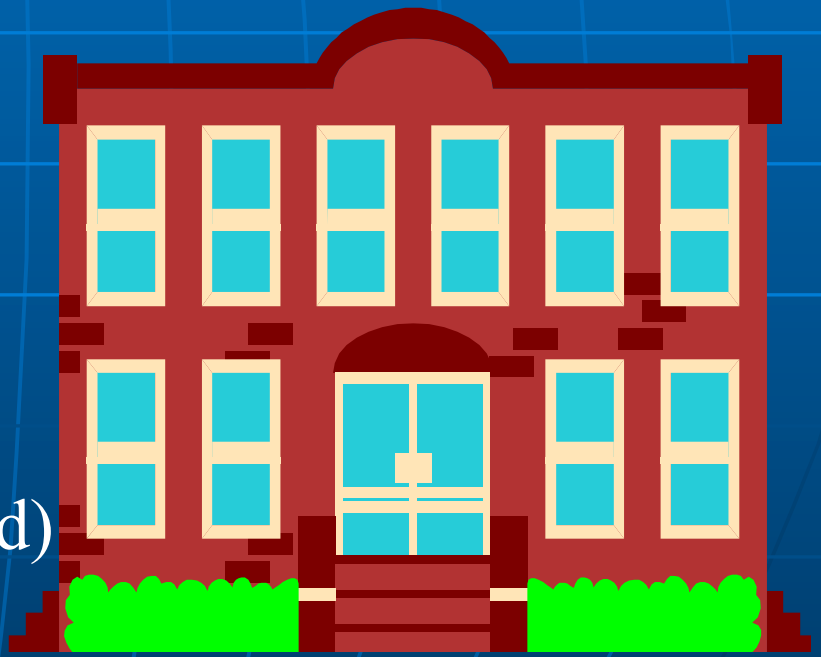


Building Automation- Technologies

- Supervision, Control, Data Acquisition (SCADA)
- Human-Machine Interface (HIM)
- Programmable Logical Controllers (PLC)

- Network
  - Cabled
  - PLC
  - Wireless

- Devices
  - Modularity (Easy to expand)
  - Interoperability



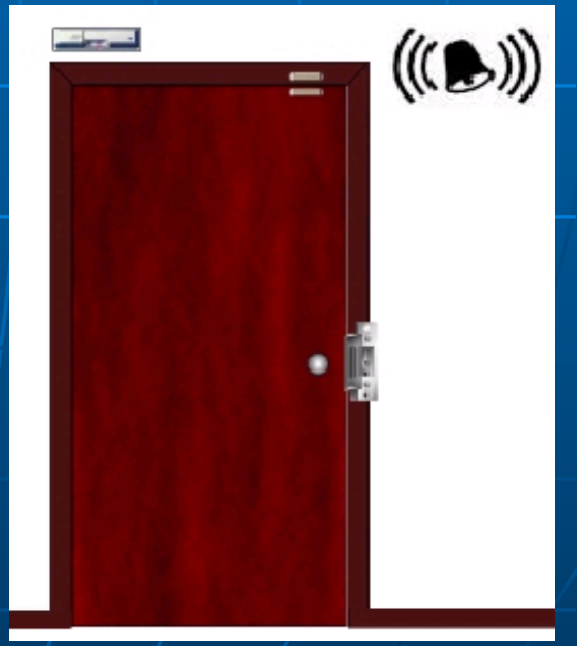
Automation Systems

- Energy Management
- Ilumination
- Access Control
- Vertical Transport
- Fire Detection and Alarm
- Air Conditioning
- Hydraulic Management
- Closed Circuit TV

Building Automation- Examples

Brazil: security > comfort

- Access Control – proximity technologies (RFID), biometry (fiber, iris, face recognition, hand geometry);
- CFTV – transmission technologies: wired, IP, Optical Fiber, Radio Frequency



Energy Saving Market

Considering ~100 buildings in Brasíl
(Airport, Hospitals, Hotels, Public Buildings, Shopping Centers etc.)

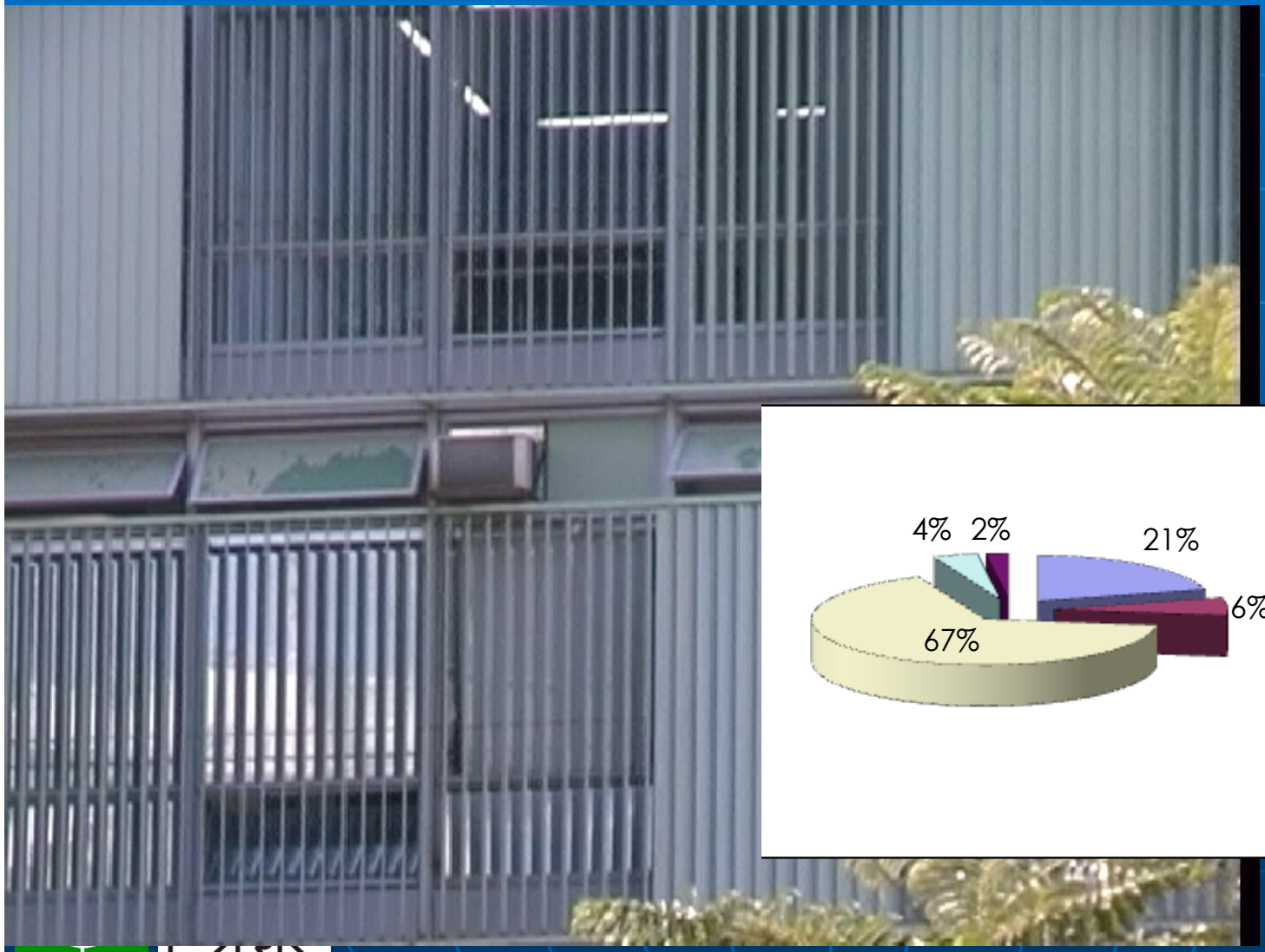
Final Usage	Médium Electrical Energy Consumption		
	Small Size	***Médium Size***	***Large Size***
Ar Conditioning	62,9 %	56,0%	48,6%
Ilumination	28,8 %	32,0%	18,5%
Elevators		3,5%	10,4%
Pumping	-	0,3%	2,5%
CPD´s, computers	7,0 %	8,0%	16,0%
Others	1,3 %	0,2%	4,0%
TOTAL	**100,0 %**	**100,0%**	**100,0%**

Metroquattro,2002

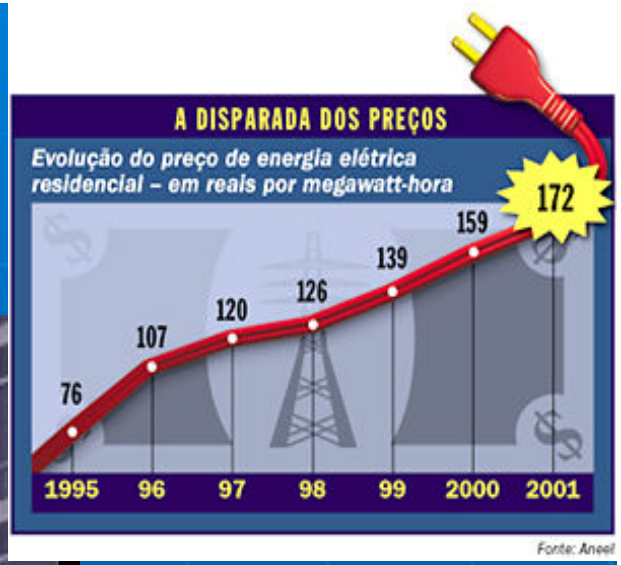
Saving Potential - Air conditioning ~ 30%
- Illumination ~ 45%

Example of a Ministry Building

- Brasília -



Energy Prices



R$/KWh

0,076 (1995)

4,7x

0,36 (2004)

0,38 (2014)

Ministério do Desenvolvimento, Indústria e Comércio Exterior

Building Automation

Design Considerations

Supervision

Command

SCADA – Supervisory Control and Data Acquisition

Supervision

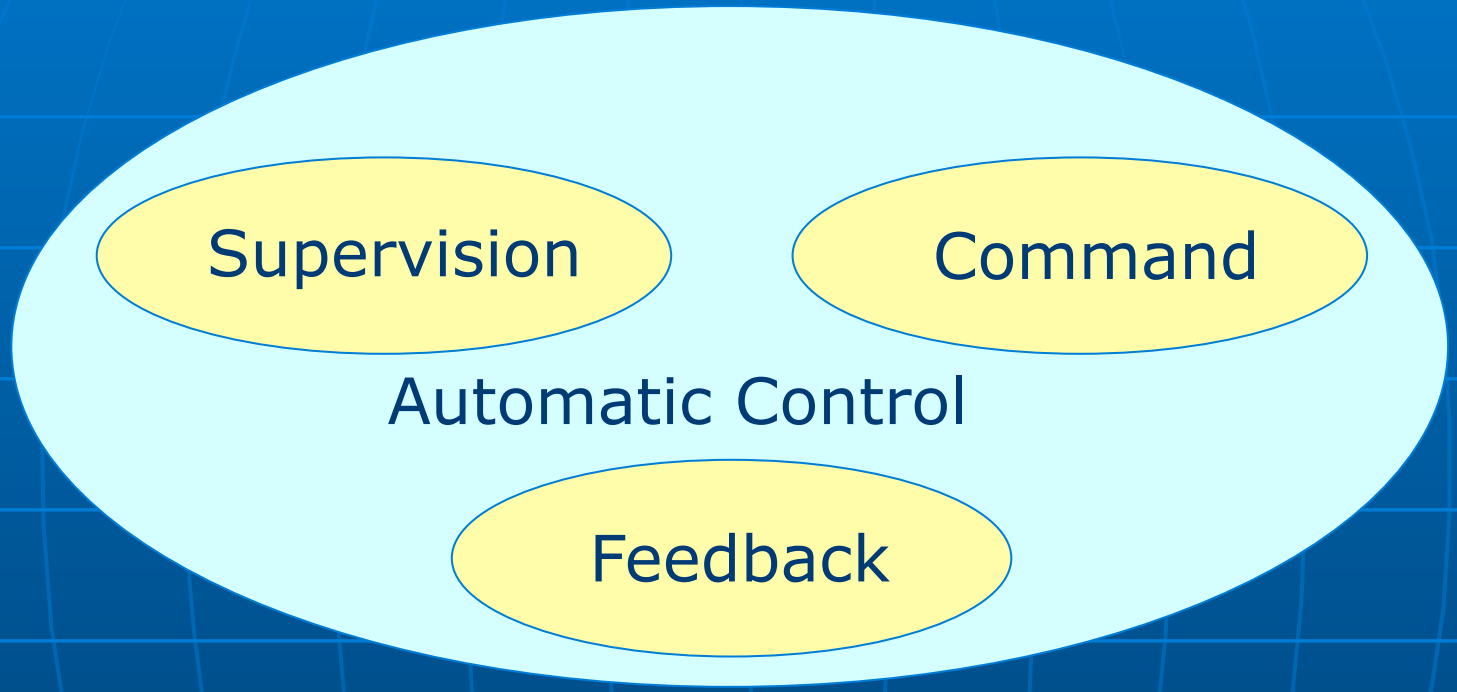
Remote Monitoring of Events

- Digital Signals
  - State of Equipments (On / Off);
  - Heating of a Transformer;
  - Level of a Reservoir (Max / Min);
- Analog Signals
  - Position of a conveyor belt;
  - Temperature of a Transformer;
  - Volume of a Reservoir;

Command

Remote Acting of a Equipment

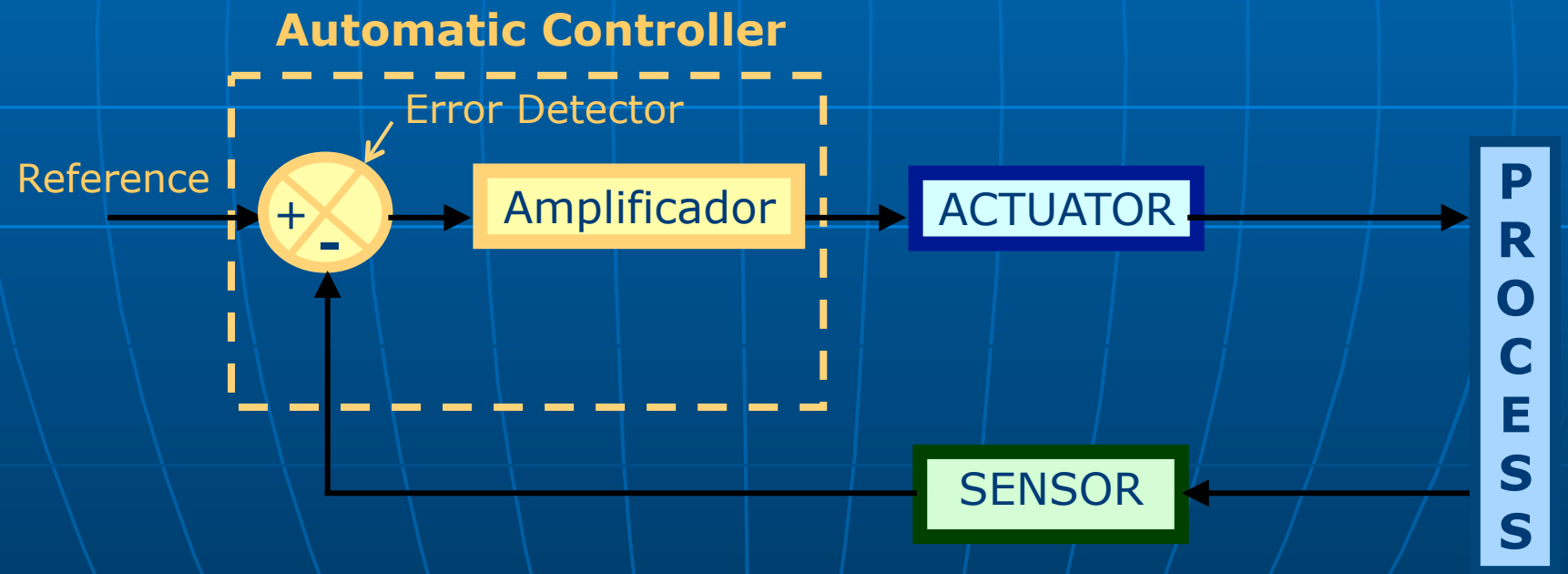
- Digital Command
  - Turn on Ilumination Circuit;
  - Turn off water pressurization pump;
  - Turn on sewage pumping;
- Analog Command
  - Put ilumination at 40% power;
  - Start water pump with 30% power;
  - Enhance pressure by 20%;


Supervision
Command
Automatic Control
Feedback

Automatic Control

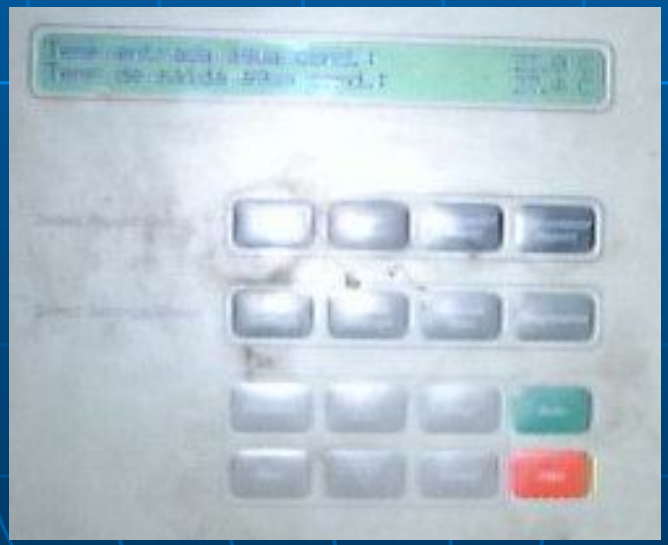
Keep a process variable at the reference value

"Compare reference and measured value then act"

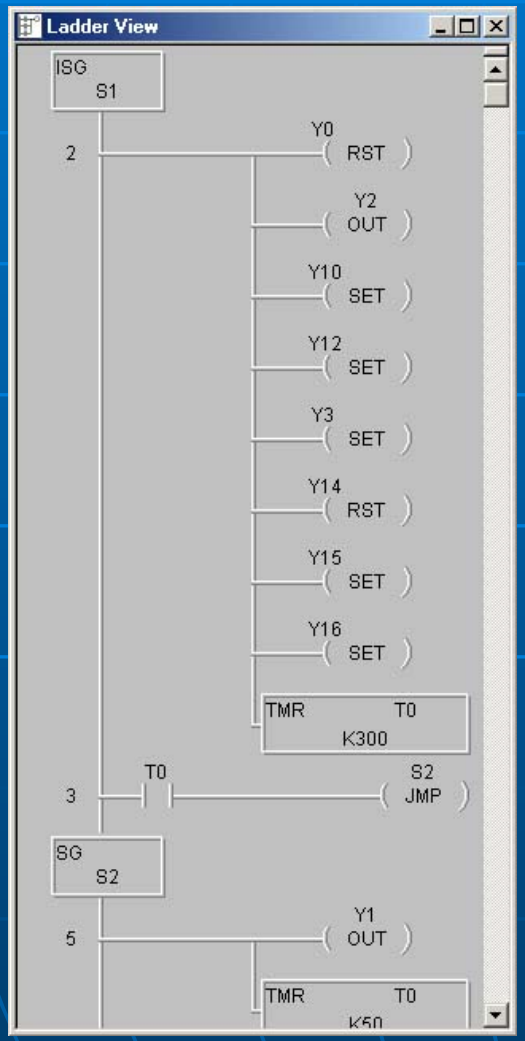


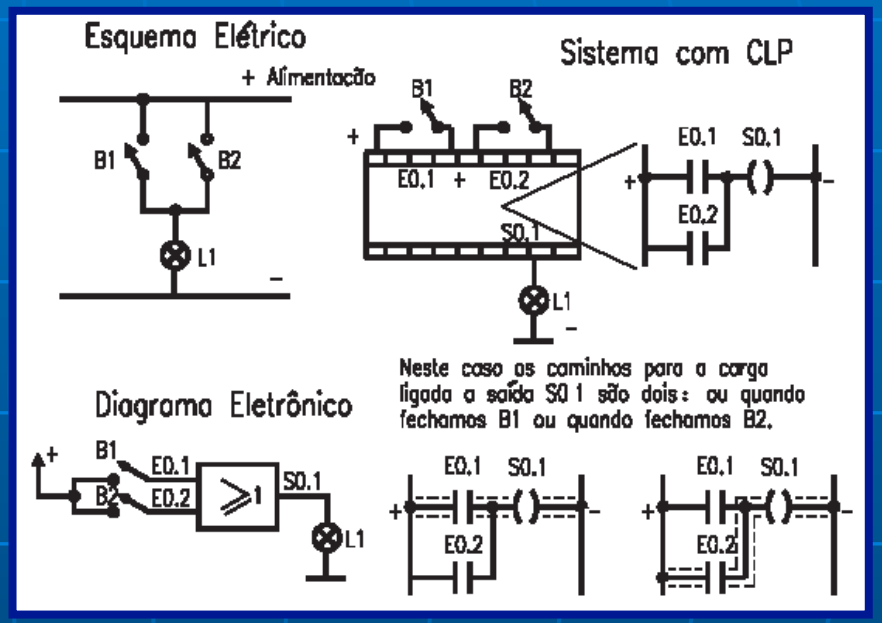
Human-Machine Interface

- Keyboard;
- Alpha-Nummeric Display;
- Sinoptic Panel;

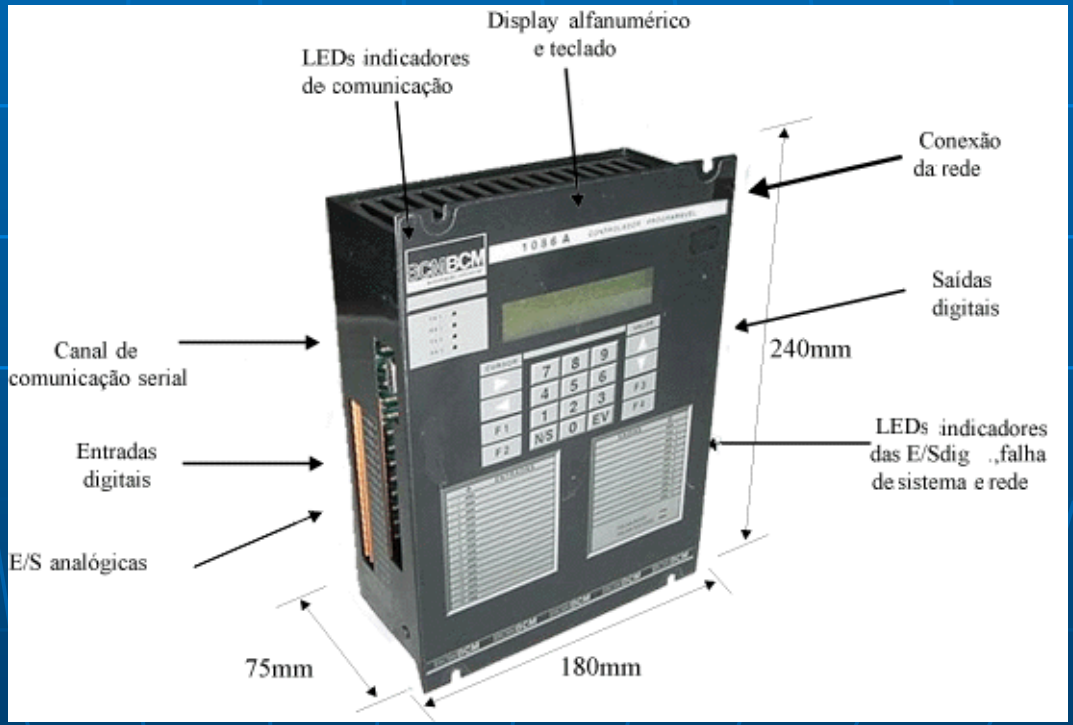


Programmble Logic Controller





PLC – Electrical Peak Demand Control



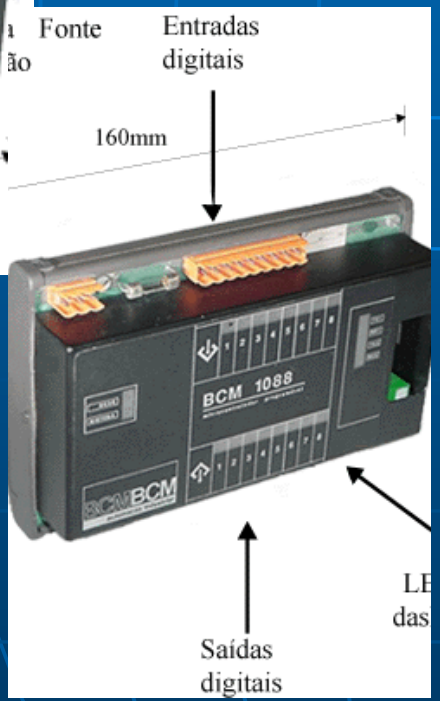
PLC - Automatic Control

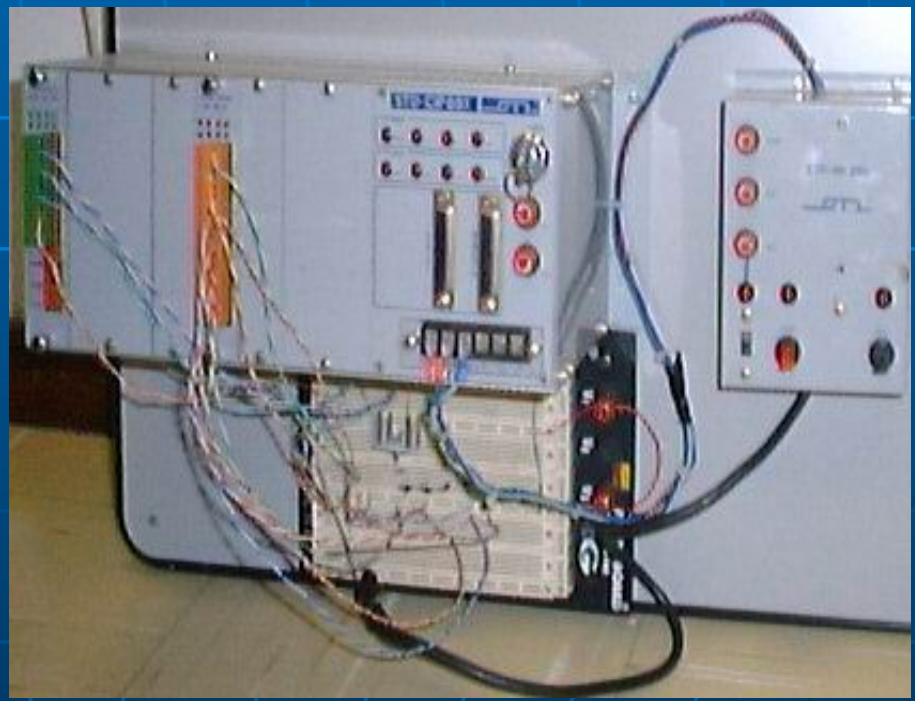
Building Cooling Unit

Some PLCs.br


483,0mm

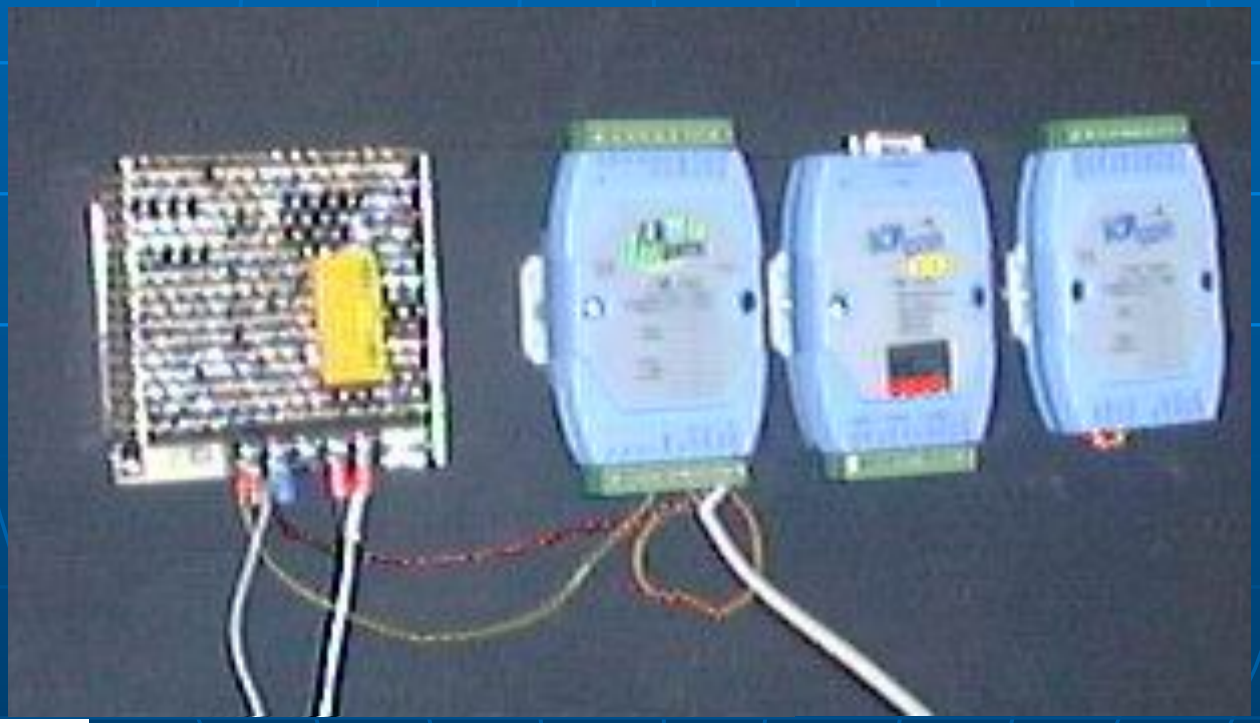

180mm


Fonte
Entradas digitais
160mm
BCM 1088
Saídas digitais

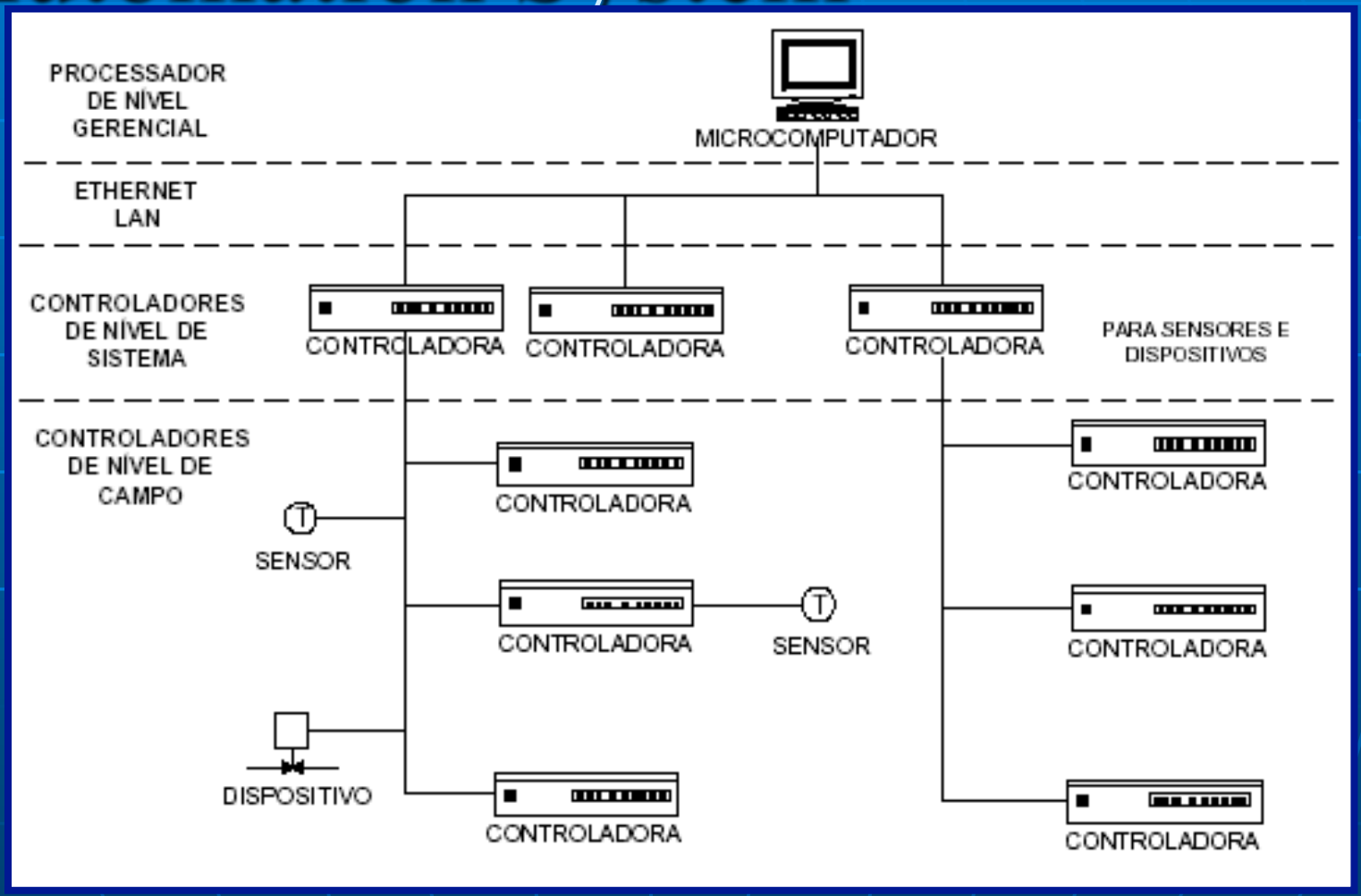


Micro **CLPs**

- **Acquisition and Control Modules**



Automation System



Some examples of

Human-Machine Interface

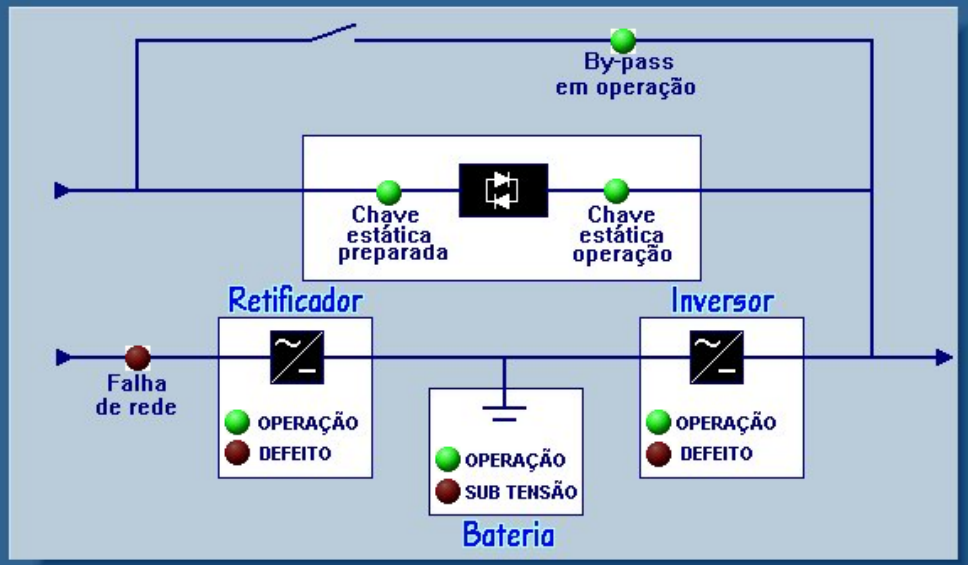
Sistema de Controle de Energia

MENU PRINCIPAL

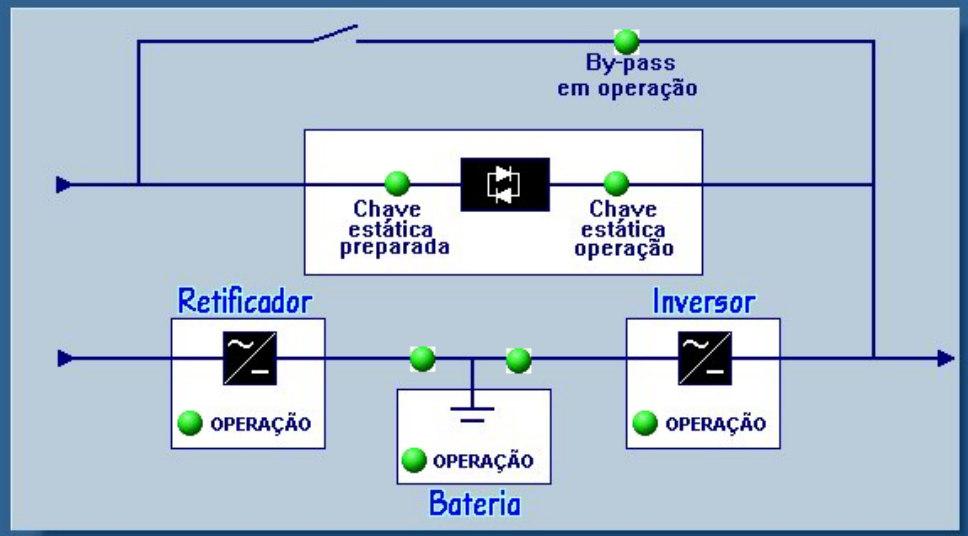
- Sistema Hidráulico
- Energia Lopes Quintas
- Energia Von Martius
- No - Break
- Relatórios
- Envia Setpoint
- Alarmes
- Elevadores
- Bancos de Capacitores
- Início
- Sair

13/8/02 1:41

Controle No Break Basys / Von Martius Cobertura



Controle No Break Basys / Von Martius Térreo

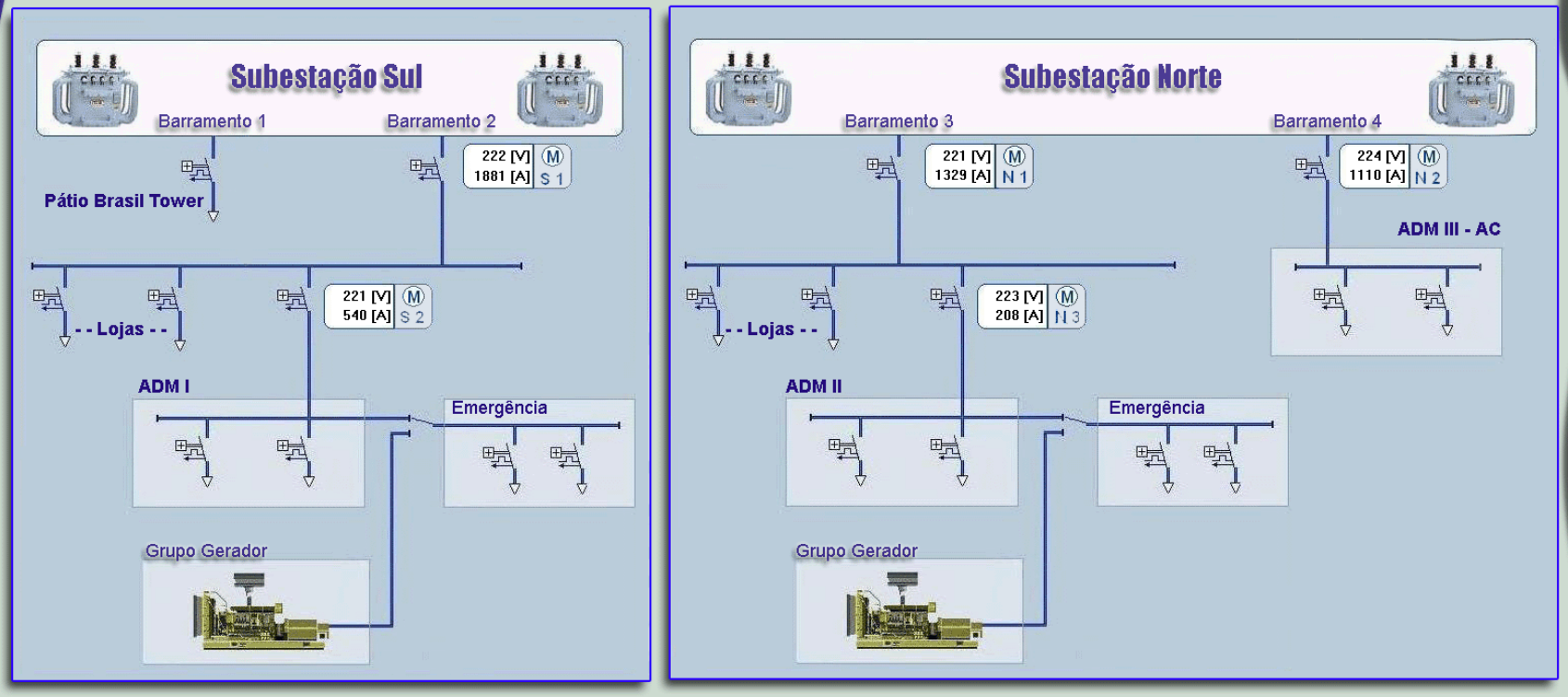


Aplicação Elipse SCADA - Energia Elétrica

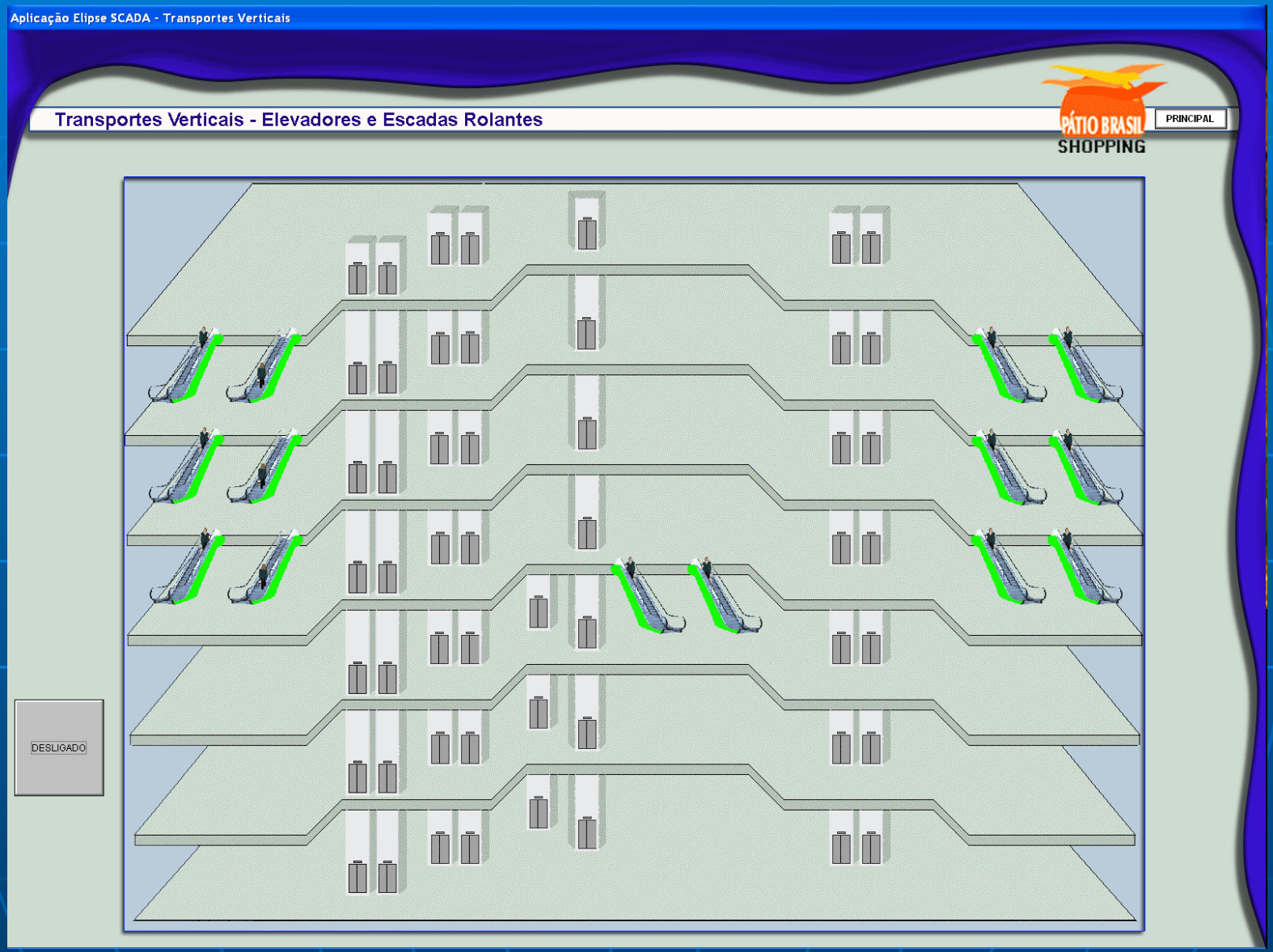
Energia Elétrica - Circuitos Alimentadores

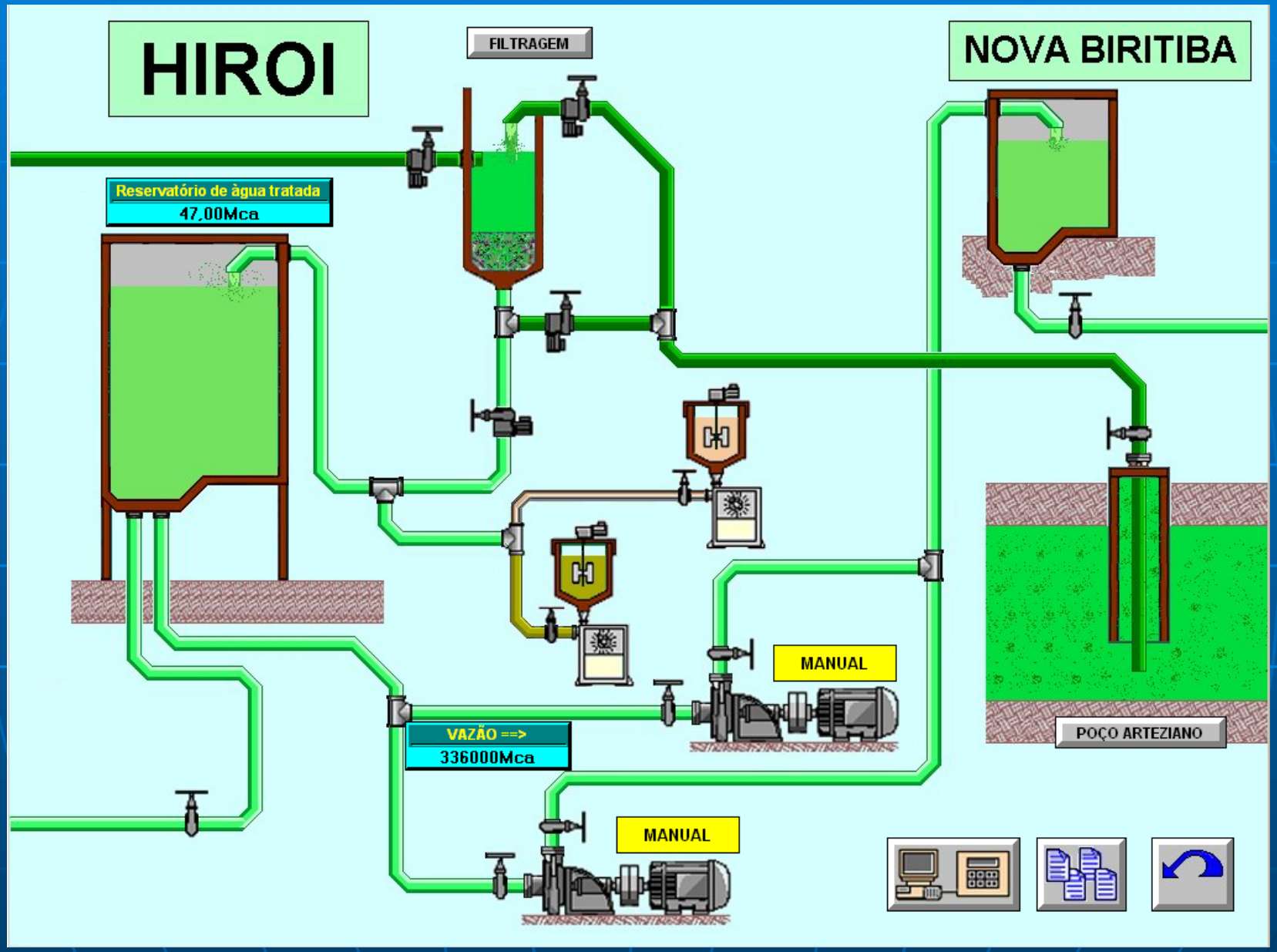
PÁTIO BRASIL SHOPPING

PRINCIPAL



	Alimentador Sul - M S1				ADM I - Medidor M S2				Alimentador Norte - M N1				ADM II - Medidor M N3				ADM III (AC) - Medidor M N2			
	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]
FASE R	220	1930	0,89	378130	220	589	0,83	107742	220	1027	0,80	180481	221	211	0,95	44343	224	1090	0,97	236051
FASE S	222	1841	0,88	358394	222	519	0,80	92869	221	1436	0,91	288350	224	184	1,00	41140	224	1161	0,95	248133
FASE T	222	1872	0,88	364930	222	511	0,79	89937	222	1526	0,90	305239	223	227	0,97	48998	225	1080	0,95	229506
MÉDIA	222	1881	0,88	101455	221	540	0,81	290548	221	1329	0,88	774071	223	208	0,97	134481	224	1110	0,96	713690


Aplicação Elipse SCADA - Transportes Verticais
Transportes Verticais - Elevadores e Escadas Rolantes
PÁTIO BRASIL
SHOPPING
PRINCIPAL
DESLIGADO


HIROI
FILTRAGEM
NOVA BIRITIBA
Reservatório de àgua tratada
47,00Mca
MANUAL
VAZÃO ==>
336000Mca
MANUAL
POÇO ARTEZIANO


Sistema de Controle de Energia
MENU PRINCIPAL
Sistema Hidráulico
Energia Lopes Quintas
Energia Von Martius
No - Break
Relatórios
Envia Setpoint
Alarmes
Elevadores
Bancos de Capacitores
Início
Sair
13/8/02 1:42
Alarmes Ativos
dd/mm/yy hh:mm:ss EstadoAlm Comentário
13/08/02 01:42:07 UNACK Fotor de Potência
13/08/02 01:38:27 UNACK
13/08/02 01:38:27 UNACK
13/08/02 01:38:27 UNACK
13/08/02 01:38:27 UNACK Demanda Min
Históricos de Alarmes
dd/mm/yy hh:mm:ss EstadoAlm Comentário
13/08/02 01:42:07 UNACK Fotor de Potência
13/08/02 01:41:57 Retornou ao Valor Normal
13/08/02 01:41:47 UNACK Fotor de Potência
13/08/02 01:41:37 Retornou ao Valor Normal
13/08/02 01:41:27 UNACK Fotor de Potência
13/08/02 01:41:17 Retornou ao Valor Normal
13/08/02 01:41:08 UNACK Fotor de Potência
13/08/02 01:40:57 Retornou ao Valor Normal
13/08/02 01:40:47 UNACK Fotor de Potência
13/08/02 01:40:37 Retornou ao Valor Normal
13/08/02 01:40:27 UNACK Fotor de Potência
13/08/02 01:40:17 Retornou ao Valor Normal


Network Viewer
DIGITAL sprite
NETWORK VIEWER
CAMERA_10
CAMERA_08
18:44:46 09/12/2002
18:44:45 09/12/2002
CAMERA_10
CAMERA_13
18:44:46 09/12/2002
18:44:45 09/12/2002
195.0.1.51
Name
IP Address
Favourites
Connect
Setup
Disconnect
Full
Event
Quad
Live
1
2
3
4
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6
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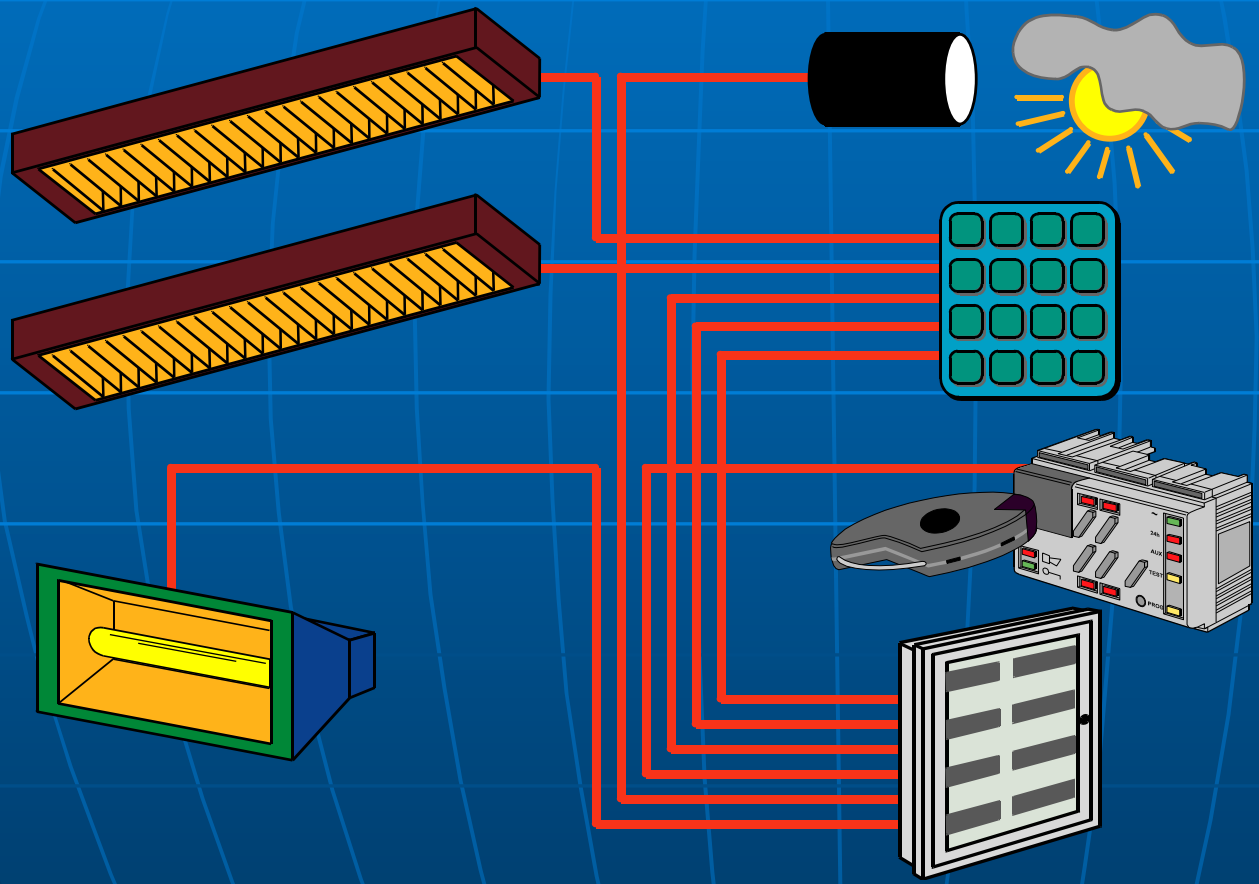
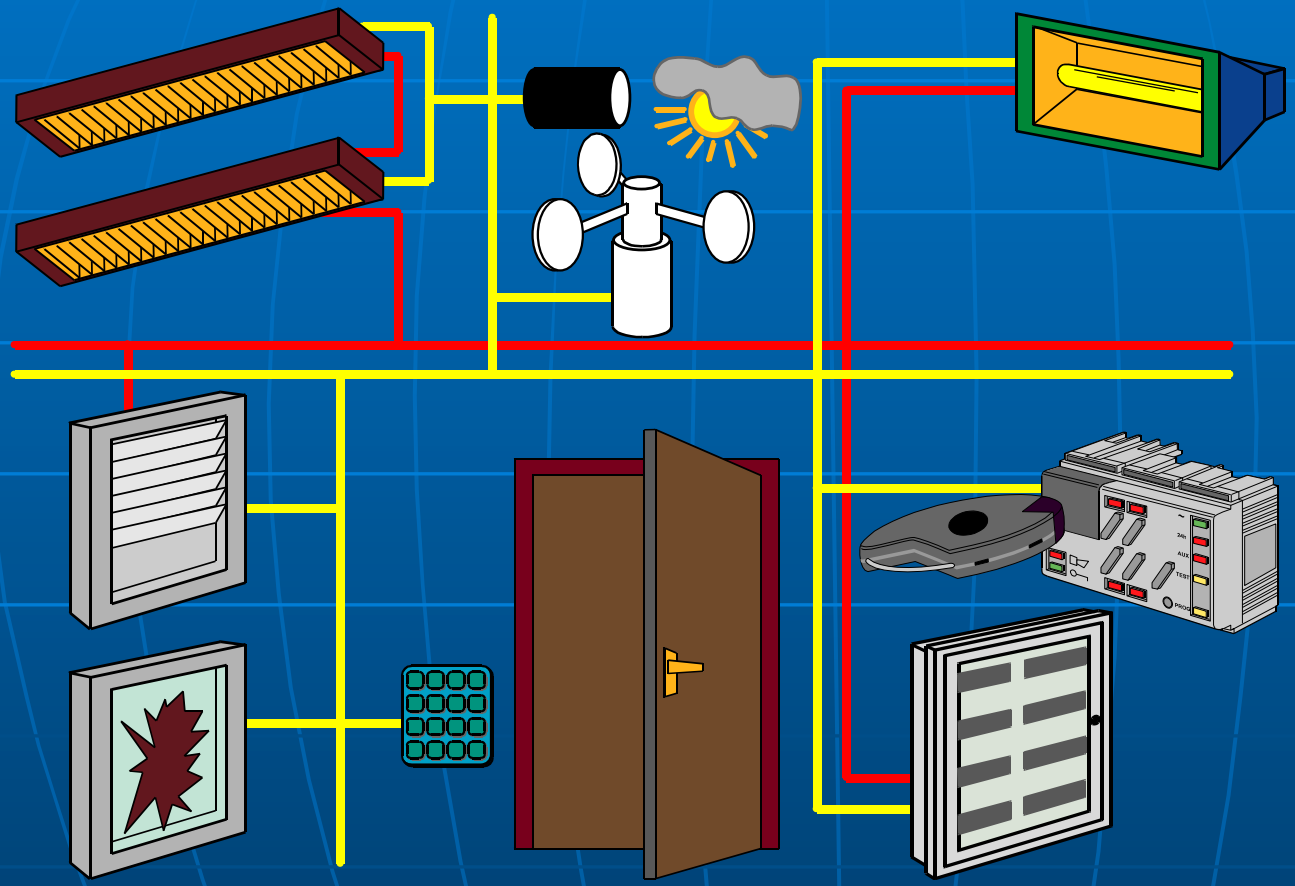
Hi
Med
Lo
DEDICATED MICROS
visit www.dedicatedmicros.com

Traditional Connection



Bus Connection

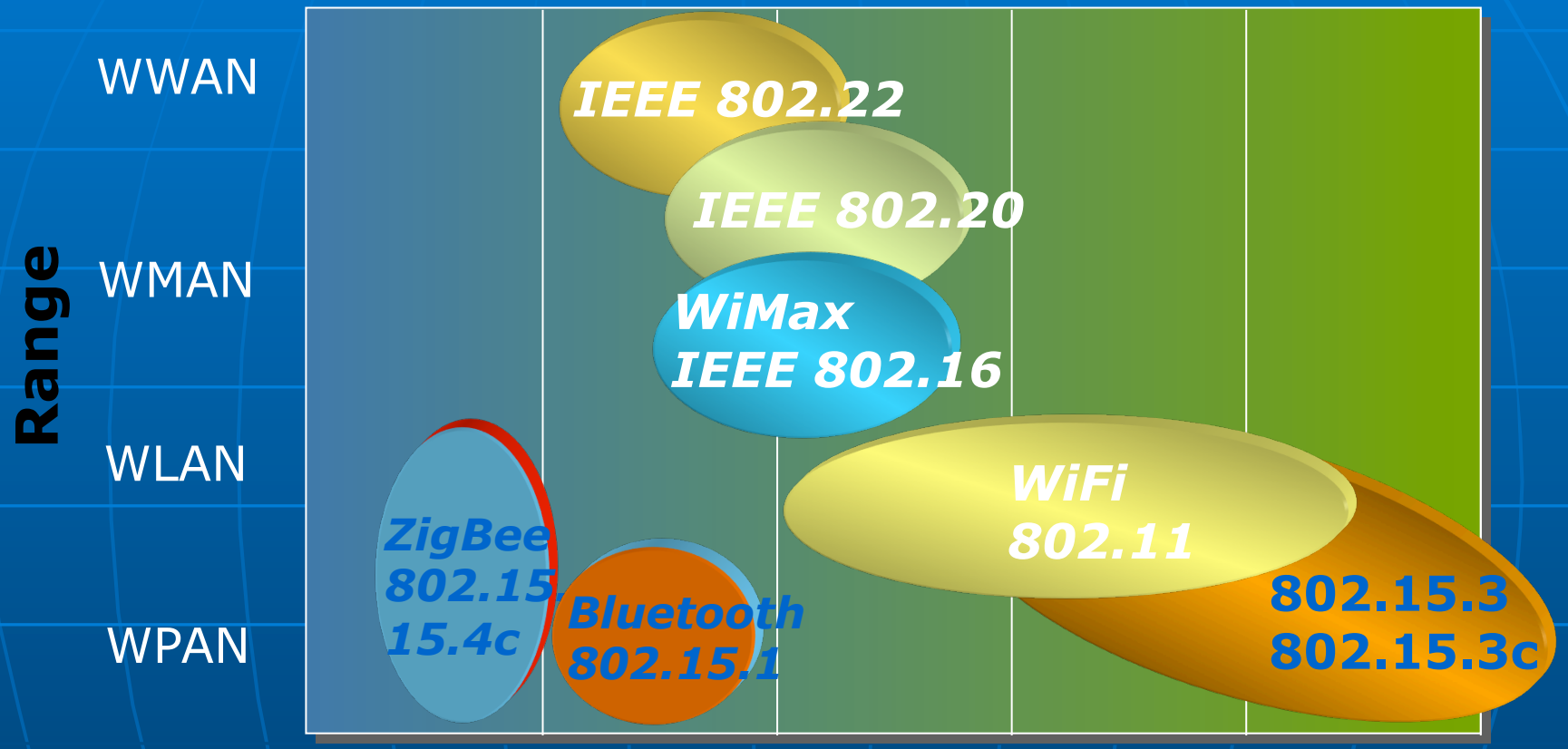


AC power line

Bus line

...wireless

The IEEE 802 Wireless Space



ZigBee fills a gap for low data rate applications

ZigBee Applications

security
HVAC
AMR
lighting control
access control

BUILDING AUTOMATION

CONSUMER ELECTRONICS

TV
VCR
DVD/CD
remote

patient
monitoring
fitness
monitoring

PERSONAL HEALTH CARE

TELECOM SERVICES

PC & PERIPHERALS

mouse
keyboard
joystick

asset mgt
process
control
environmental
energy mgt

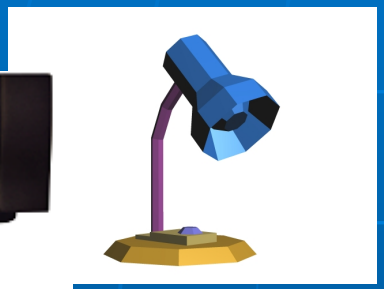
INDUSTRIAL CONTROL

m-commerce
info services
object interaction
(Internet of Things)

HOME CONTROL

security
HVAC
lighting control
access control
irrigation

ZigBee Mesh Networking



Slide Courtesy of

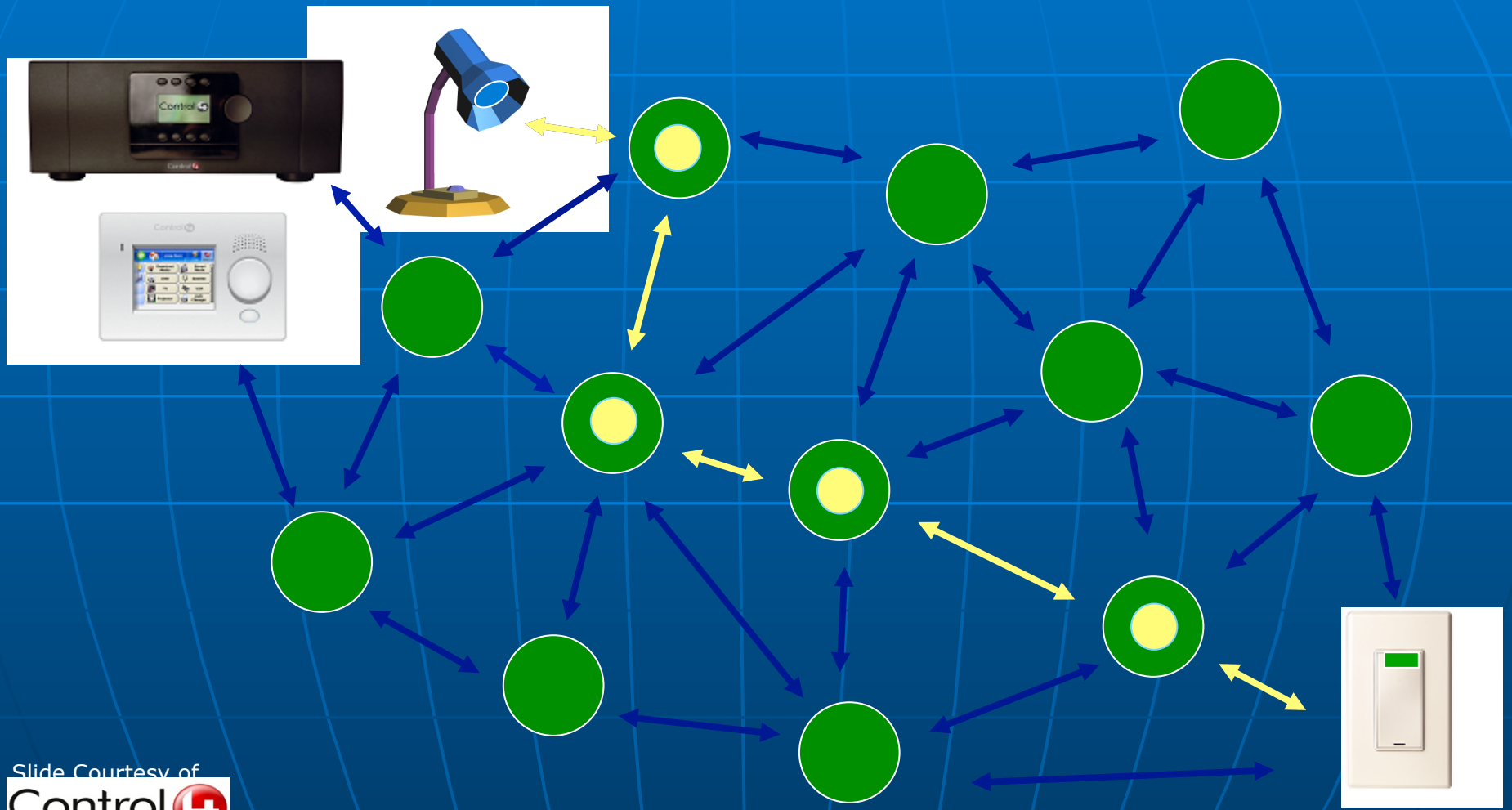
Control 4

ZigBee Mesh Networking

Slide Courtesy of

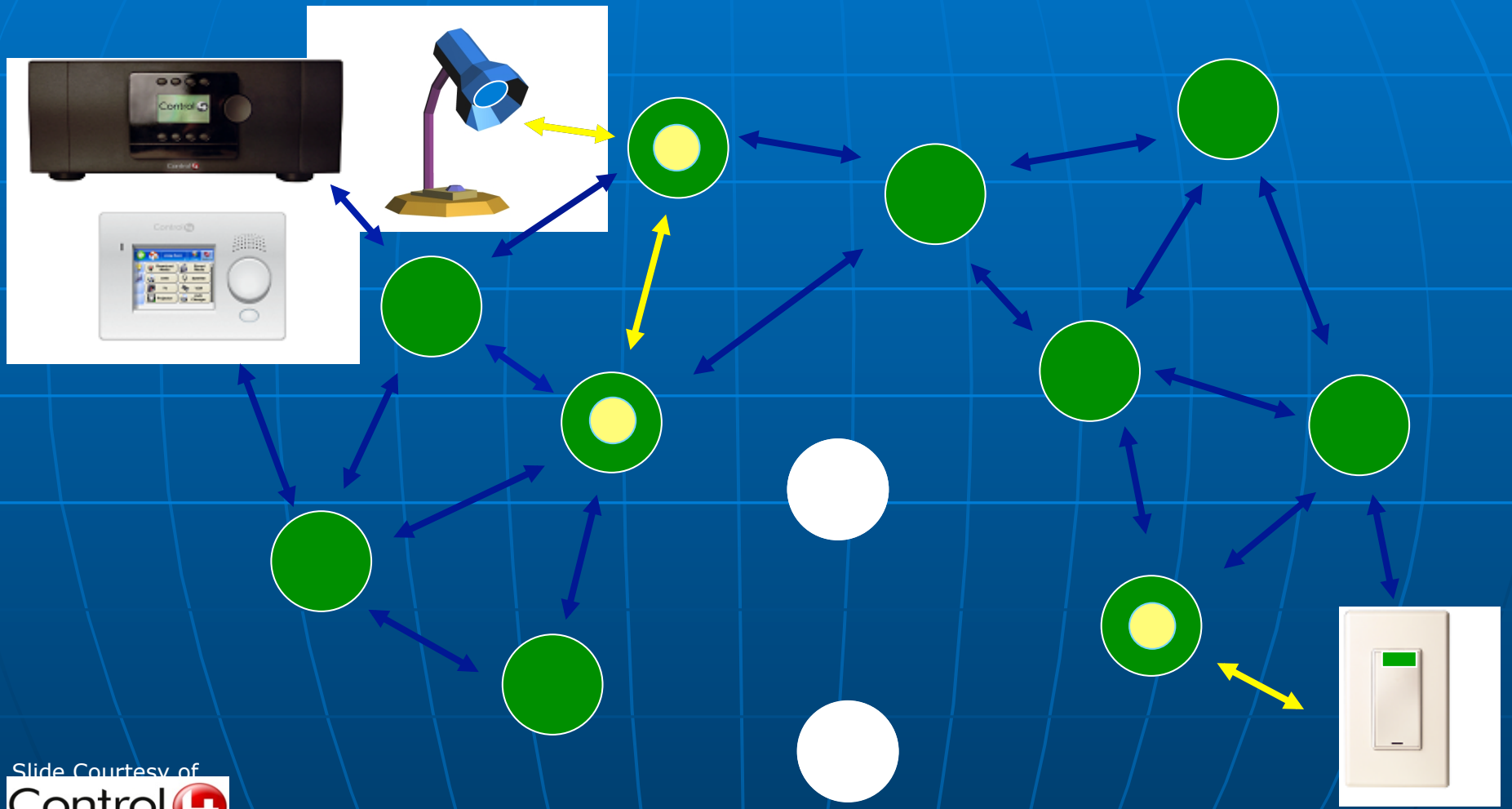
Control 4

ZigBee Mesh Networking



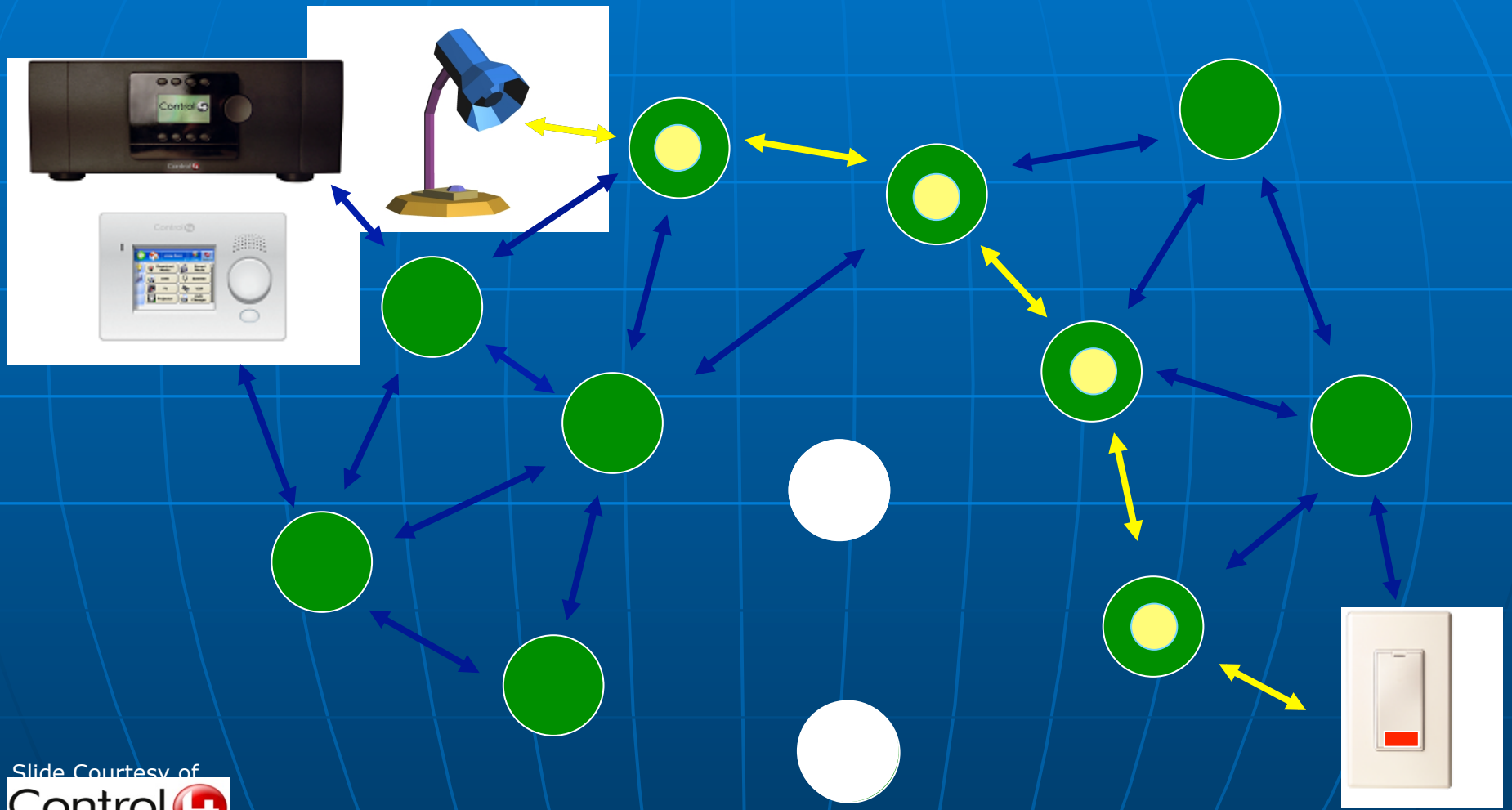
Slide Courtesy of Control 4

ZigBee Mesh Networking



Slide Courtesy of Control 4

ZigBee Mesh Networking

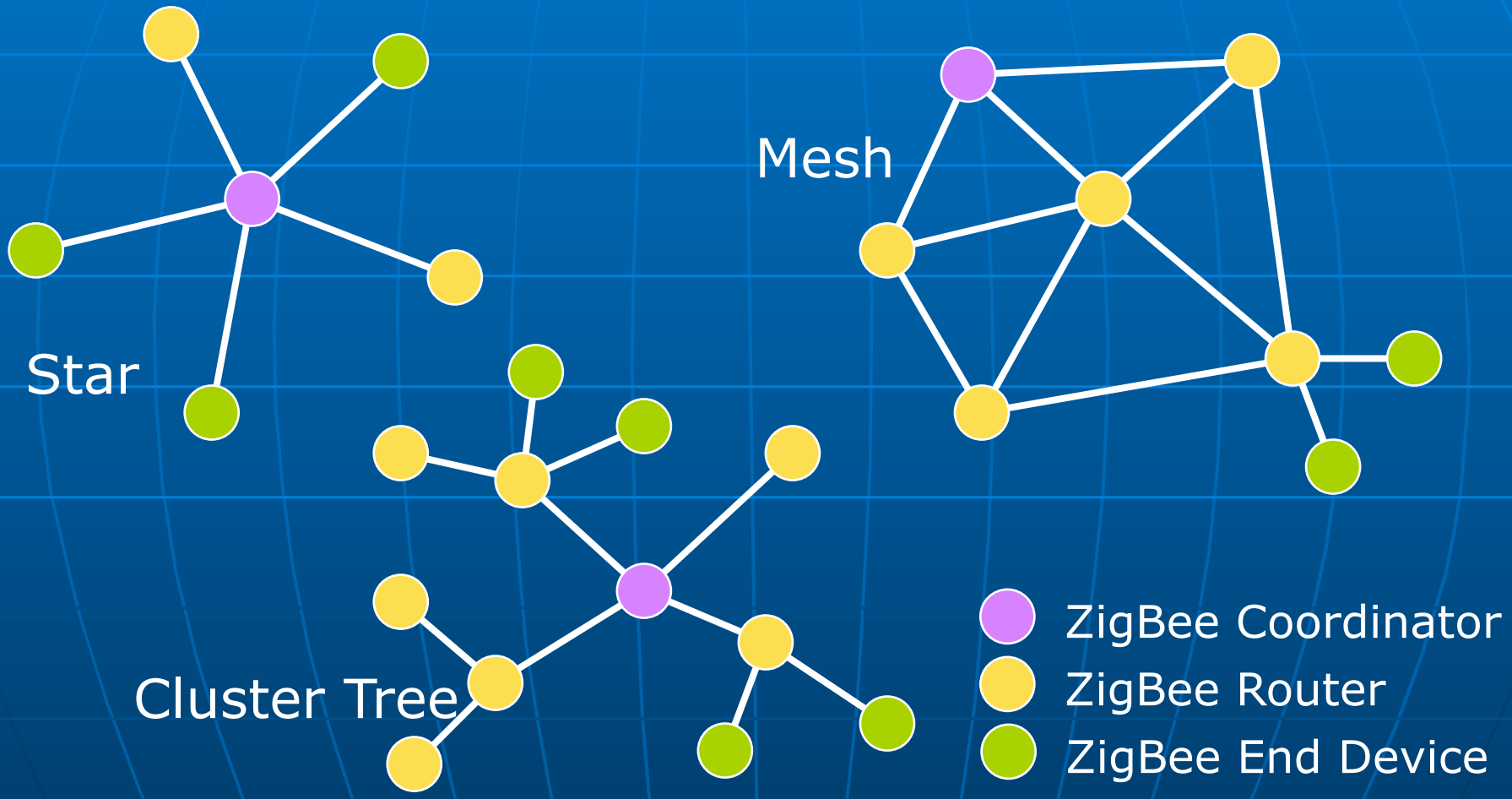


Slide Courtesy of Control 4

ZigBee Device Types

- ZigBee Coordinator (ZC)
  - One required for each ZB network.
  - Initiates network formation.
- ZigBee Router (ZR)
  - Participates in multihop routing of messages.
- ZigBee End Device (ZED)
  - Does not allow association or routing.
  - Enables very low cost solutions


ZigBee Network Topologies

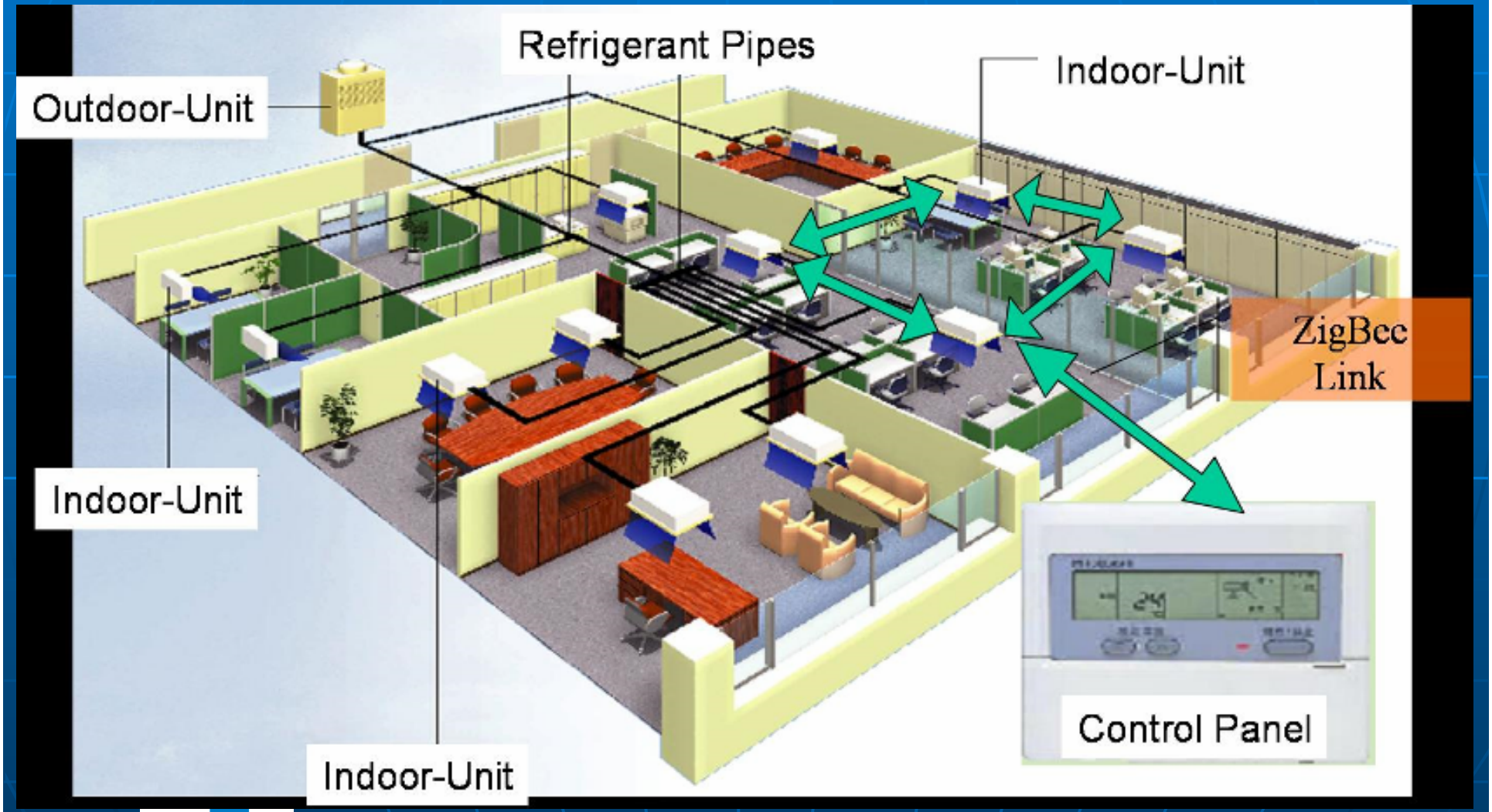


Some Application Profiles

- Home Automation [HA]
  - Defines set of devices used in home automation
    - Light switches
    - Thermostats
    - Window shade
    - Heating unit
    - etc.

- Industrial Plant Monitoring
  - Consists of device definitions for sensors used in industrial control
    - Temperature
    - Pressure sensors
    - Infrared
    - etc.

Climatization Example



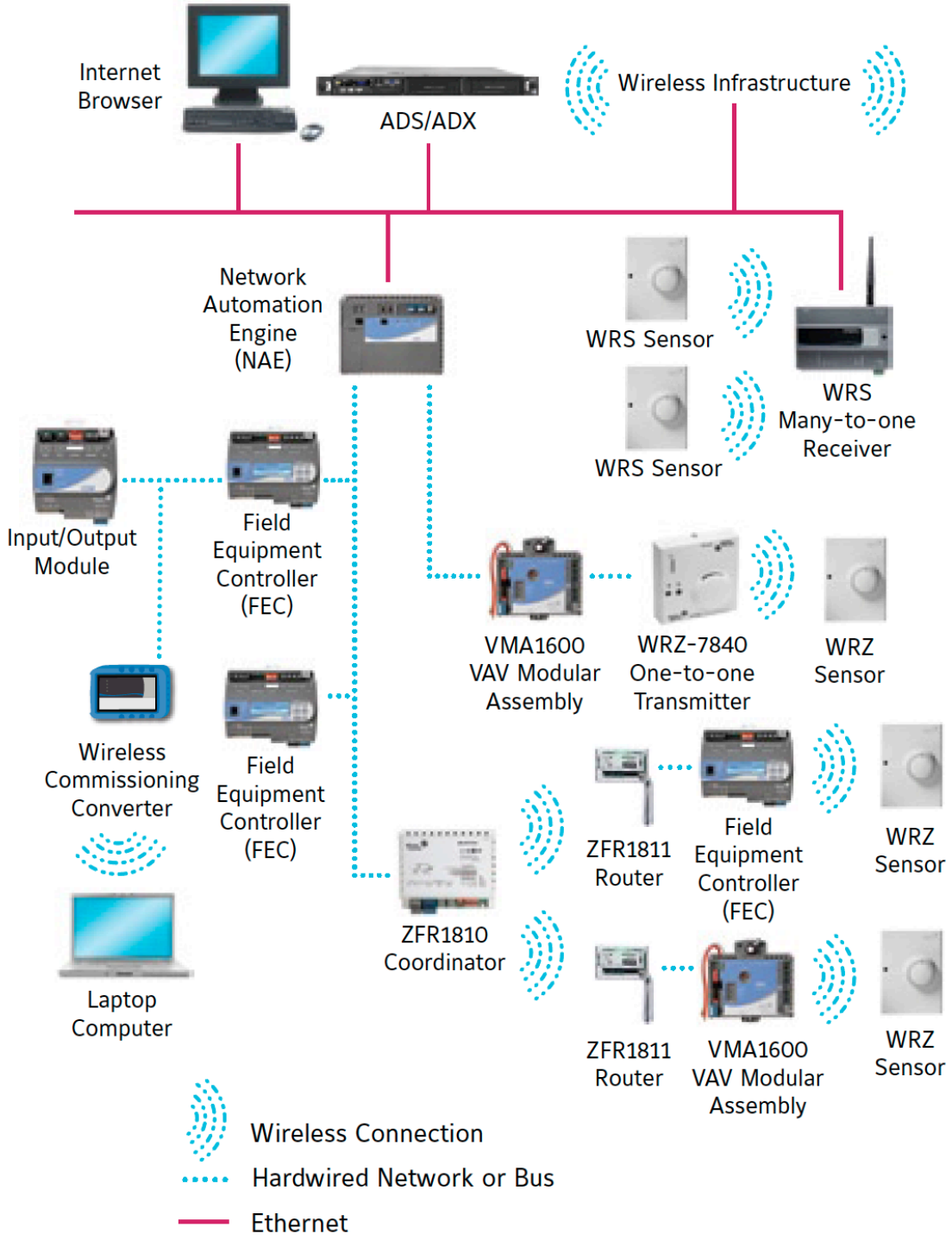
Commercial Lighting Control

- Wireless lighting control
  - Dimmable intelligent ballasts
  - Light switches/sensors anywhere
  - Customizable lighting schemes
  - Quantifiable energy savings
  - Opportunities in residential, light commercial and commercial
- Extendable networks
  - Lighting network can be integrated with and/or be used by other building control solutions

Example WASN:

(Wireless Actuator and Sensor Network)

Wireless Room Temperature Sensing System



Johnson Controls

LARA

- **Ambient Intelligence**
- Control, Estimation & Applications
- Field Robotics
- Human-Centered Robotics

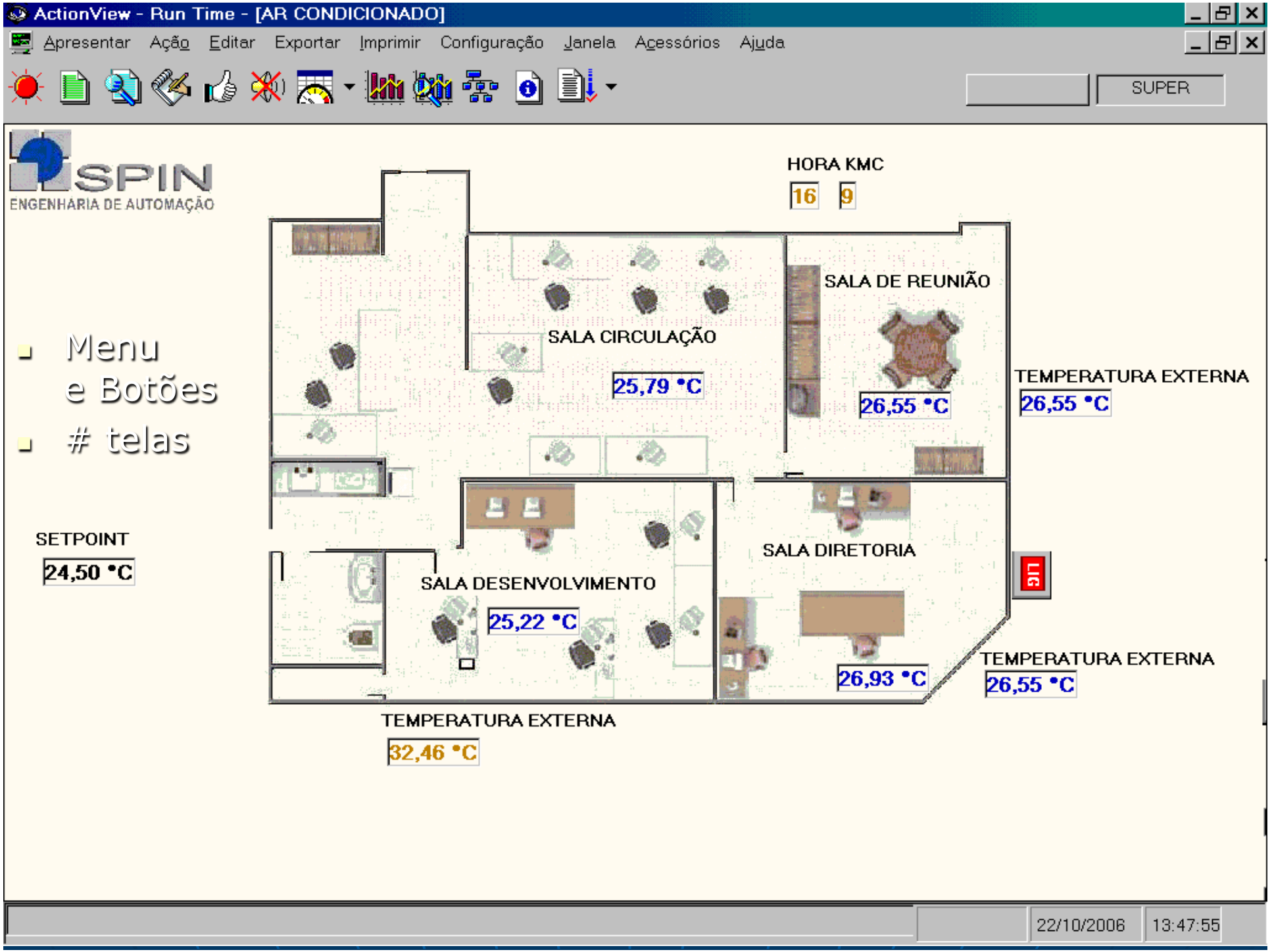
Some Projects at LARA/UnB

LabInov

The main objective of the LabInov project is to create an ambient intelligence laboratory for validation of innovations in the area. Besides that, it should help in the process of technology transfer between the university and companies. This project is a cooperation between the University of Brasília and Spin Engenharia de Automação Ltda

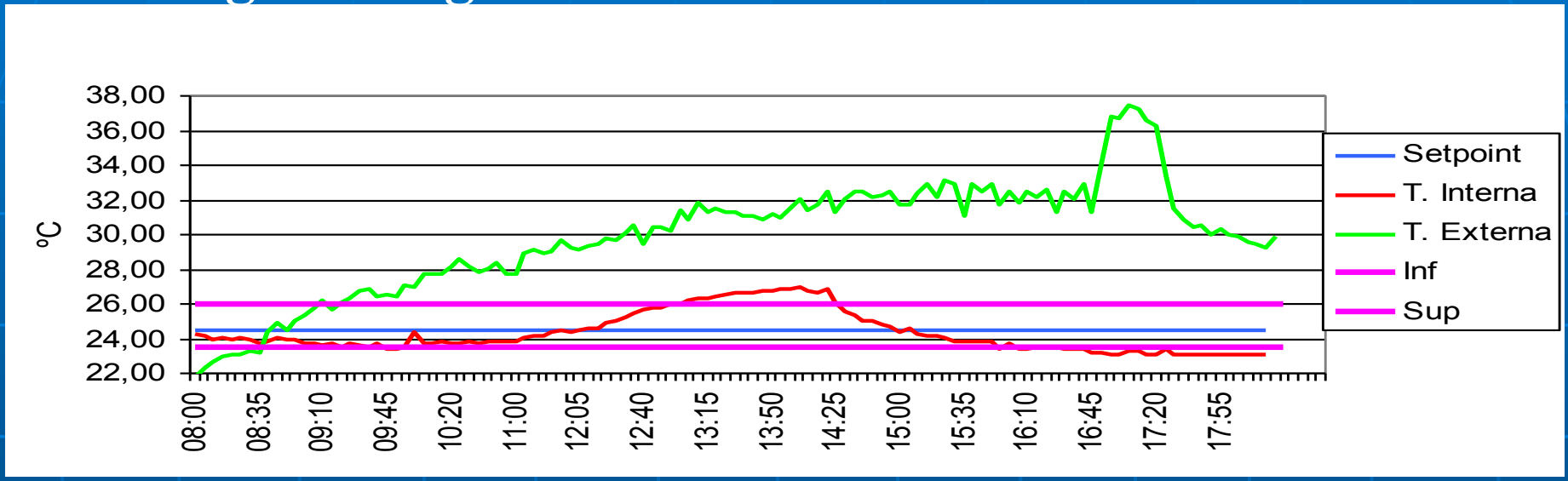
Highly Interacting Ambient Systems

In Ambient Systems, wireless networks are applied to promote information exchange among the different nodes of the ambient system network. This project goals are to answer existing theoretical questions and to reveal and bridge gaps between theory and praxis in interacting ambient systems. It is a cooperation between the University of Brasília and the University of Kaiserslautern

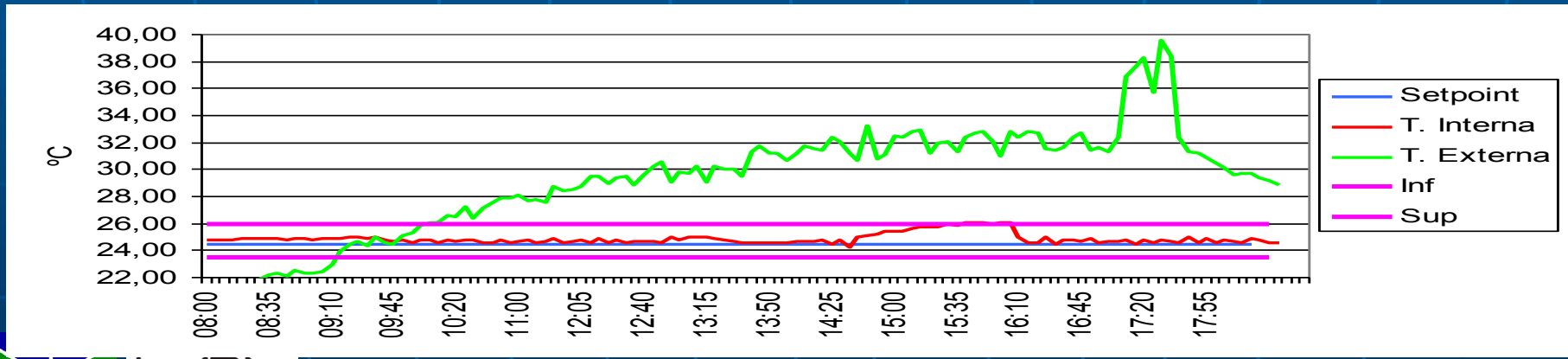

ActionView - Run Time - [AR CONDICIONADO]
Apresentar Ação Editar Exportar Imprimir Configuração Janela Acessórios Ajuda
SUPER
SPIN
ENGENHARIA DE AUTOMAÇÃO
HORA KMC
16 9
Menu e Botões
telas
SALA CIRCULAÇÃO
25,79 °C
SALA DE REUNIÃO
26,55 °C
TEMPERATURA EXTERNA
26,55 °C
SETPOINT
24,50 °C
SALA DIRETORIA
SALA DESENVOLVIMENTO
25,22 °C
LIG
26,93 °C
TEMPERATURA EXTERNA
26,55 °C
TEMPERATURA EXTERNA
32,46 °C
22/10/2006
13:47:55

Development Room

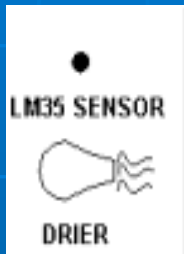
Liga-Desliga 16-09-2006

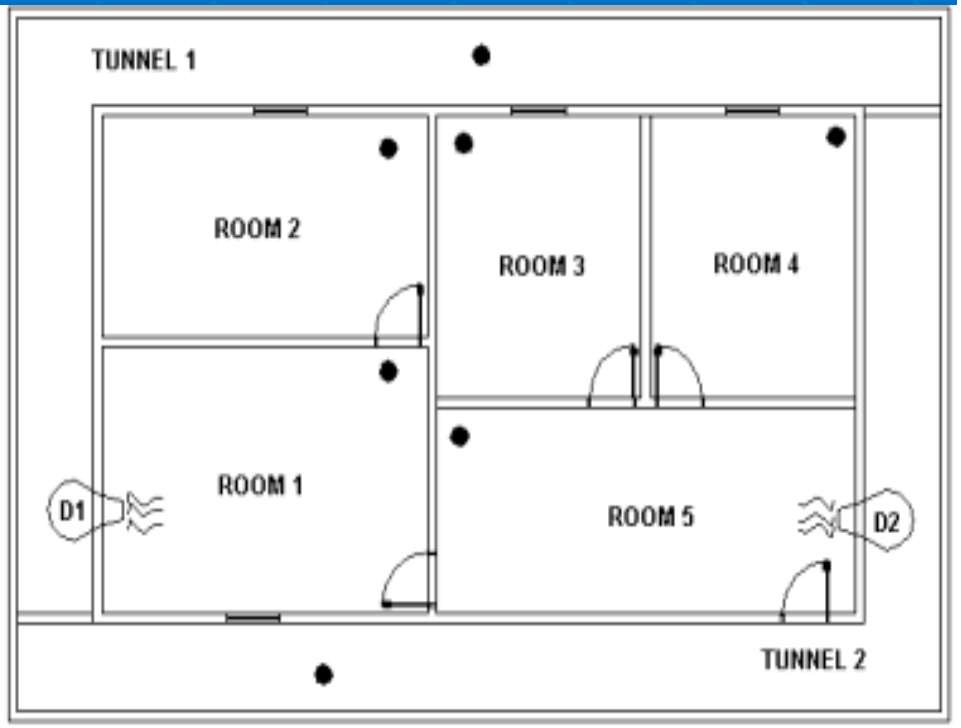


Fuzzy Control 14-09-2006

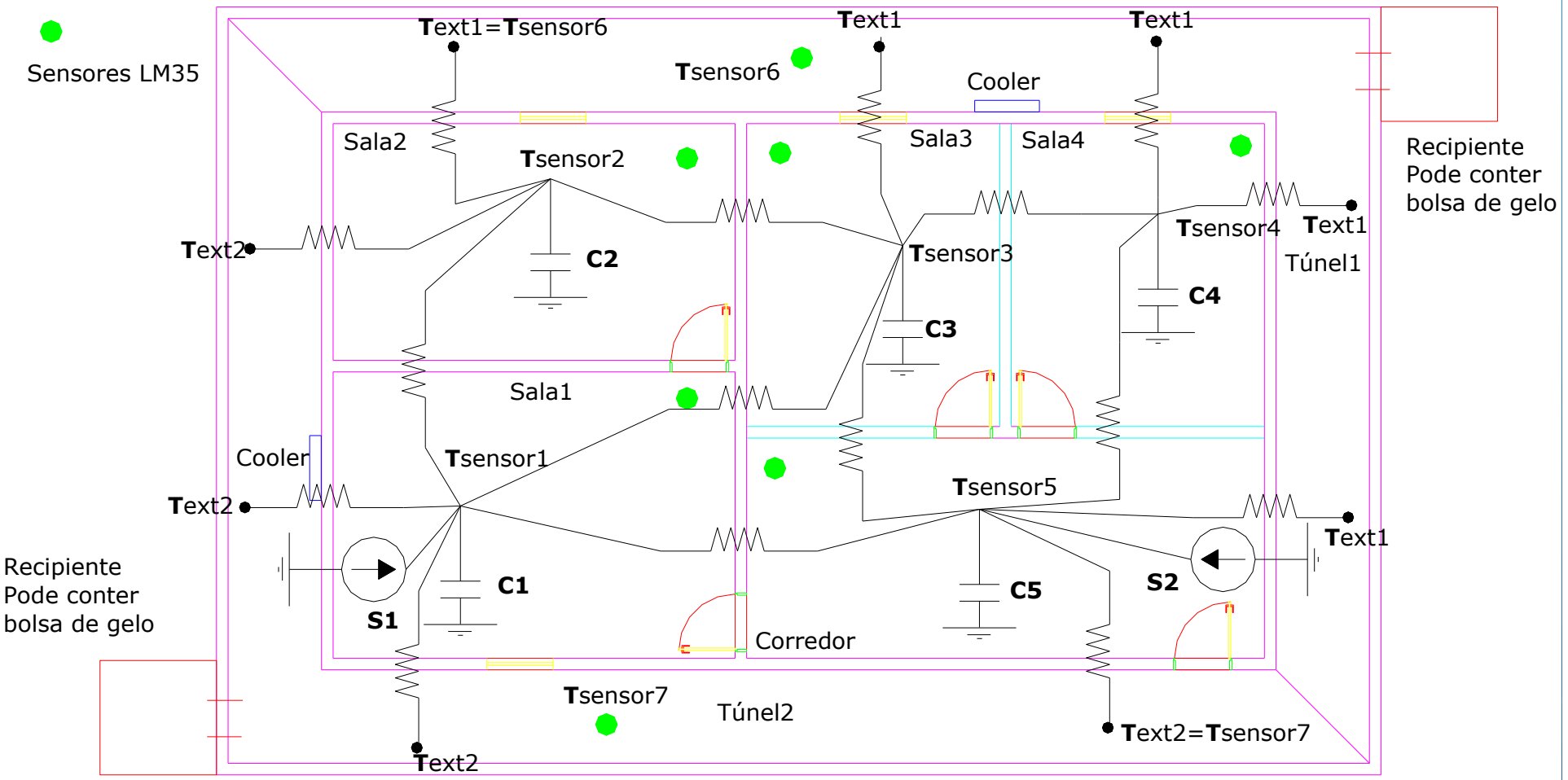


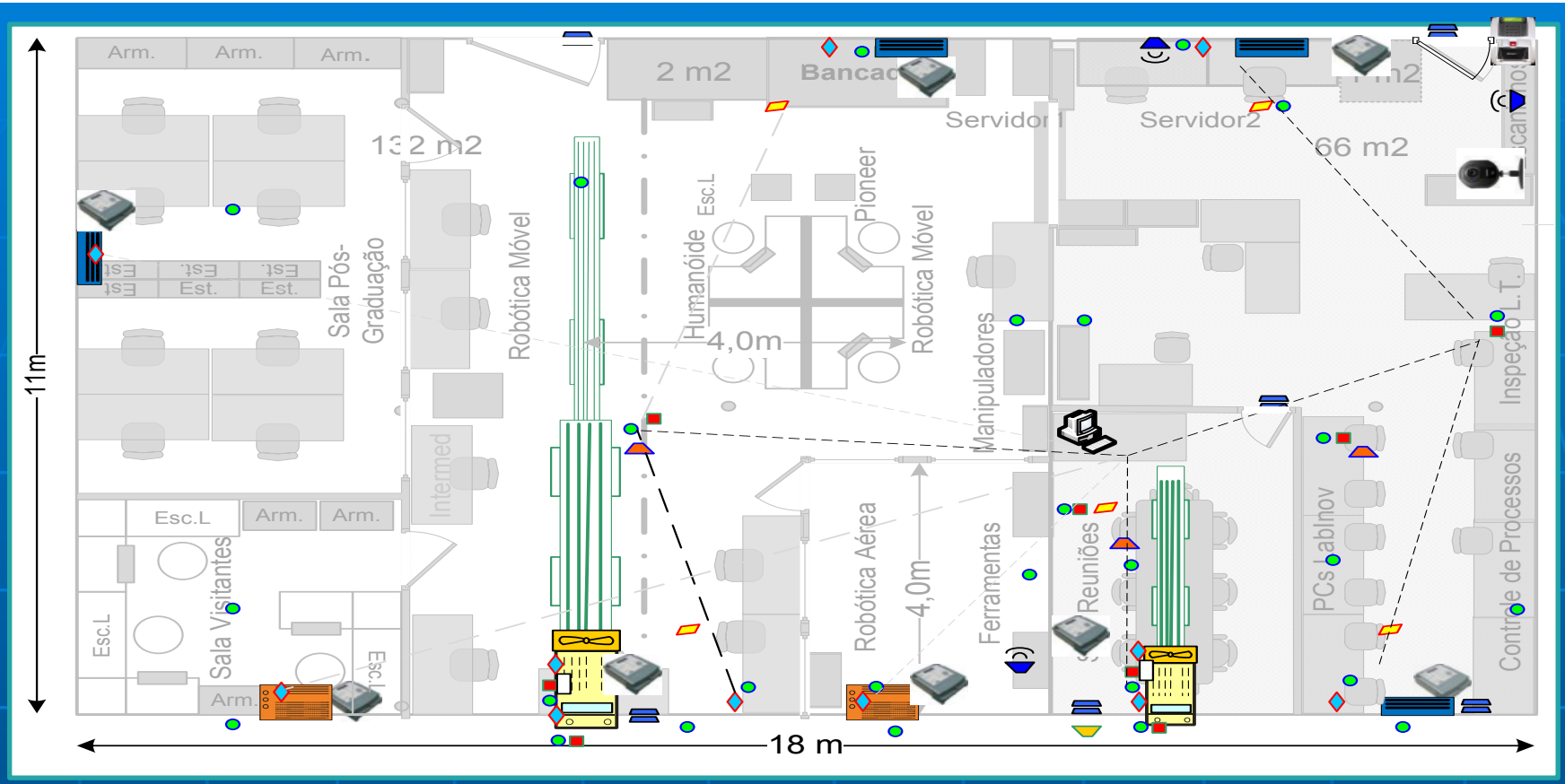
Prototype of a Thermal System





Analog Circuit - Thermal Process





- Sensor de Temperatura
- Sensor de Umidade
- Anemômetro
- Sensor Radiação Térmica Média
- Piranômetro
- Atuador Ar Cond.
- Detector de Presença
- Detector Porta/Janela aberta
- Medidor de Energia
- Camera de Vigilância
- Controle de Acesso
- BAS - Building Automation System

LARA

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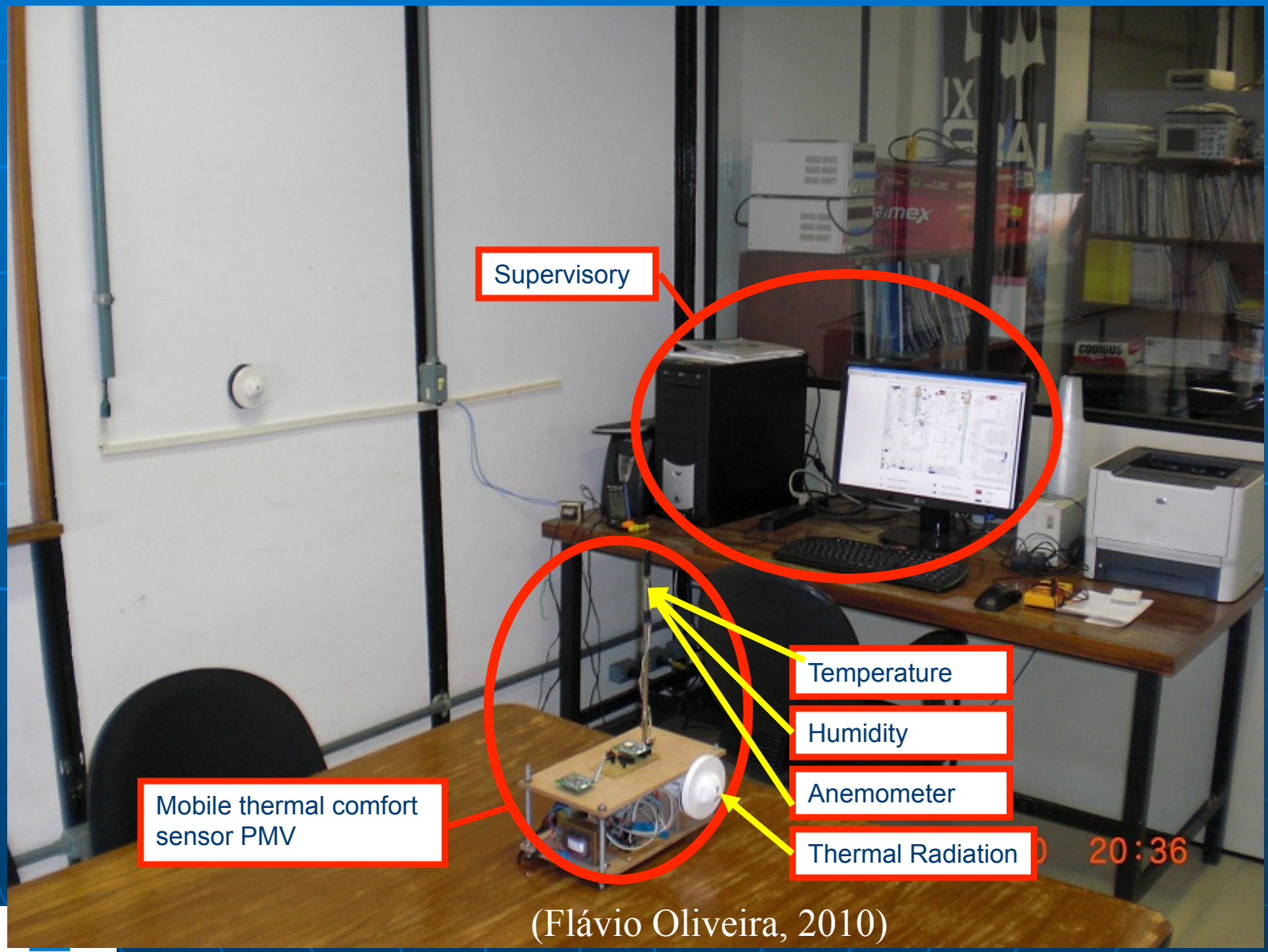
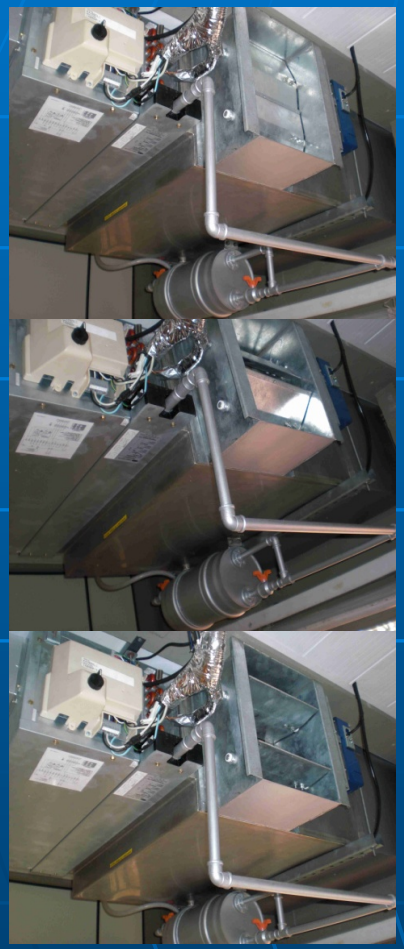
Mobile Thermal Comfort sensor

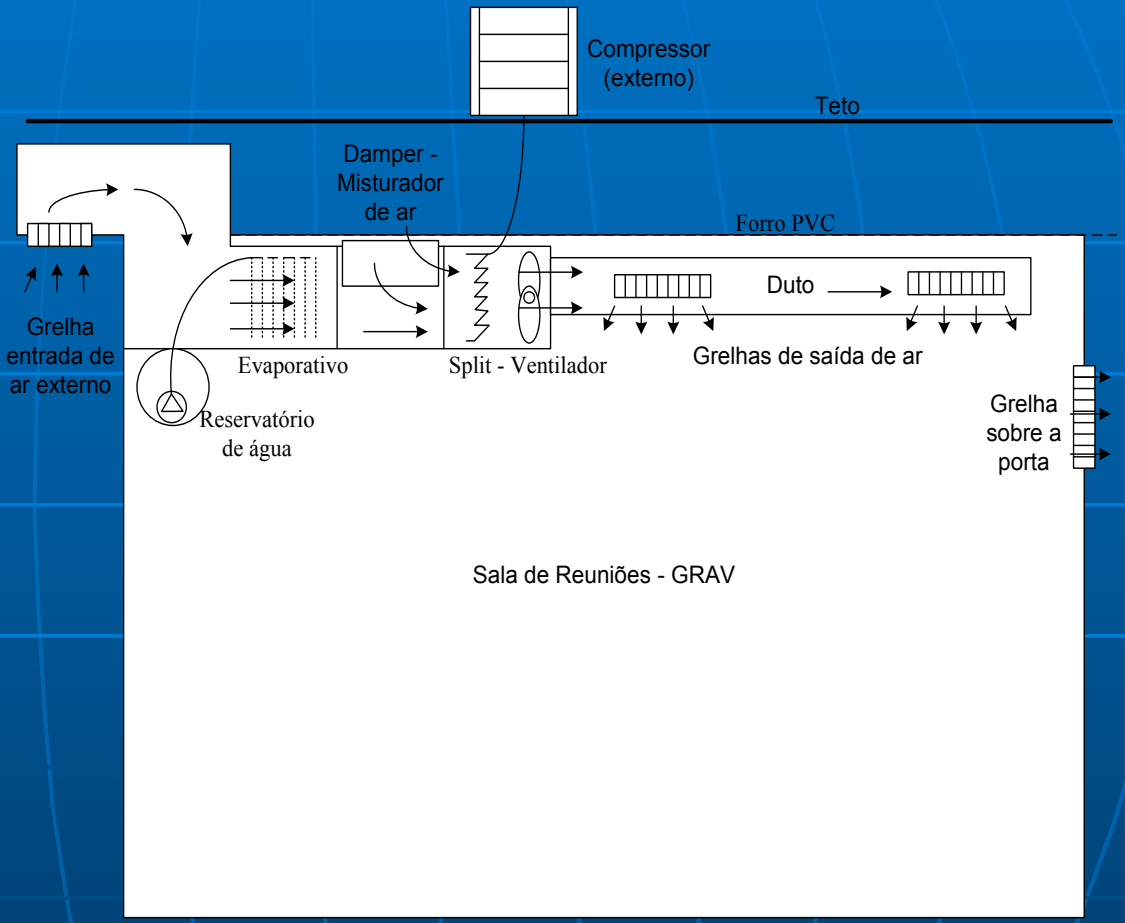


(Flávio Oliveira, 2010)

Hybrid Climatization

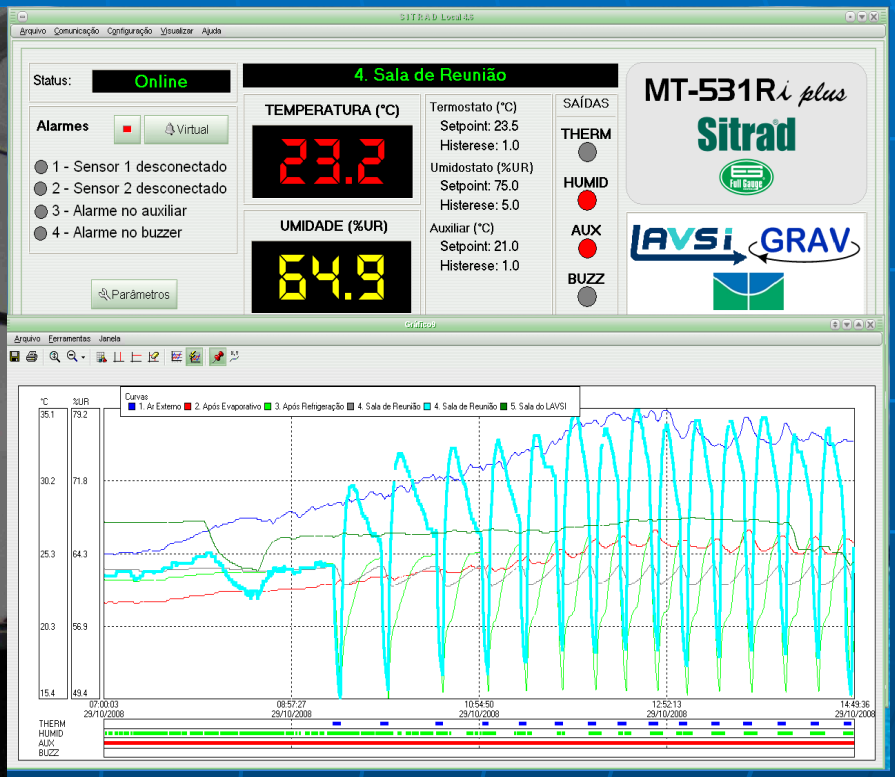


Damper



(José Luís Olmos, 2009)

Hybrid Climatization: Evaporative-Conventional



(José Luís Olmos, 2009)

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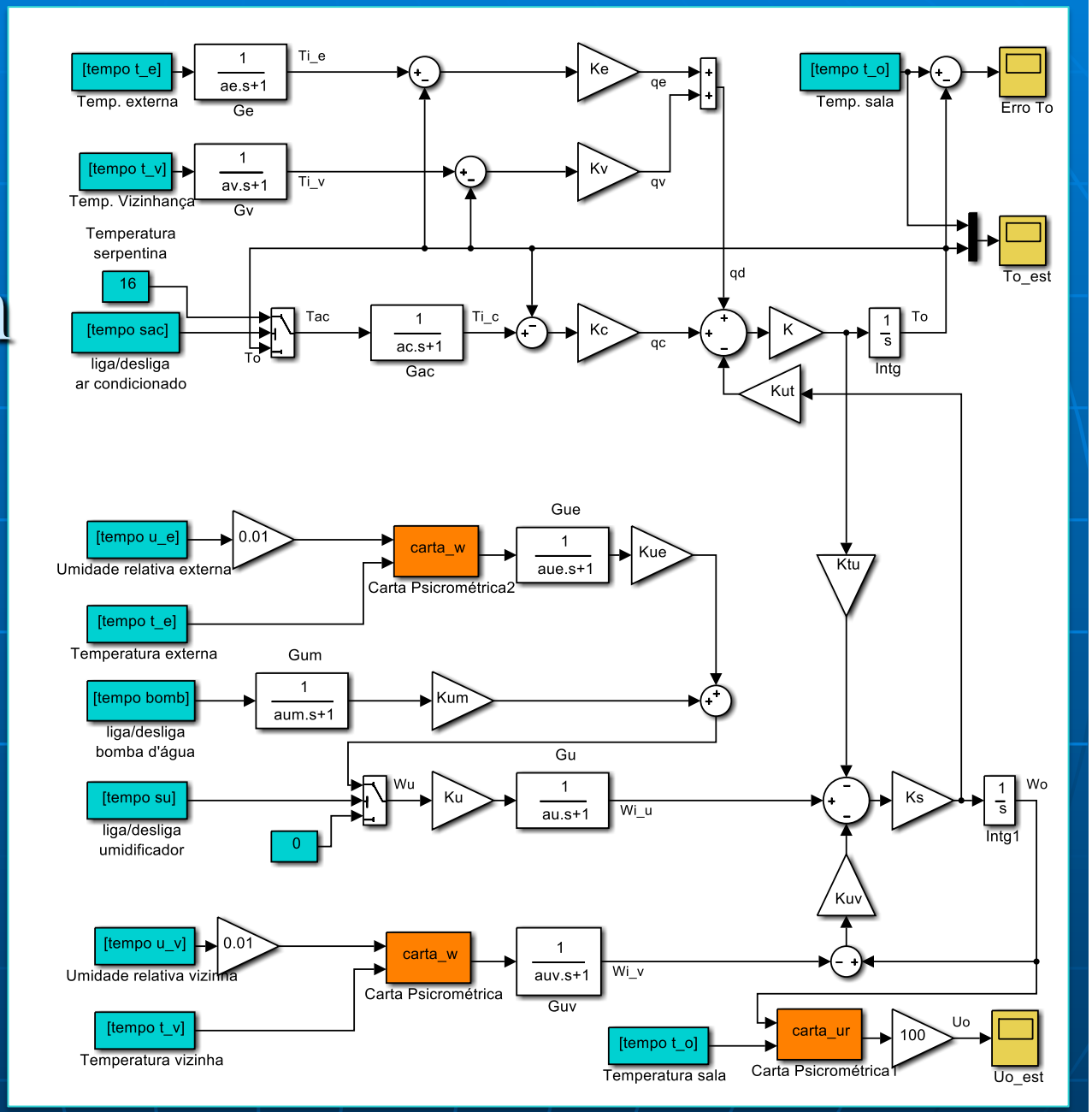
First-Principles Identification

Tempeture & Humidity

→ Optimal Hybrid Climatization

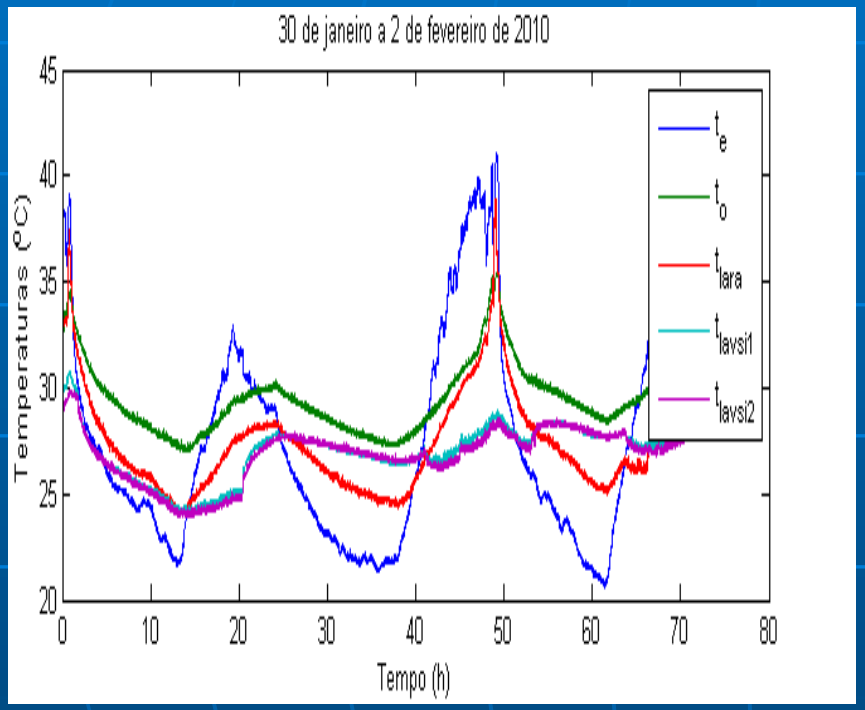
(Pedro Vianna, 2013)



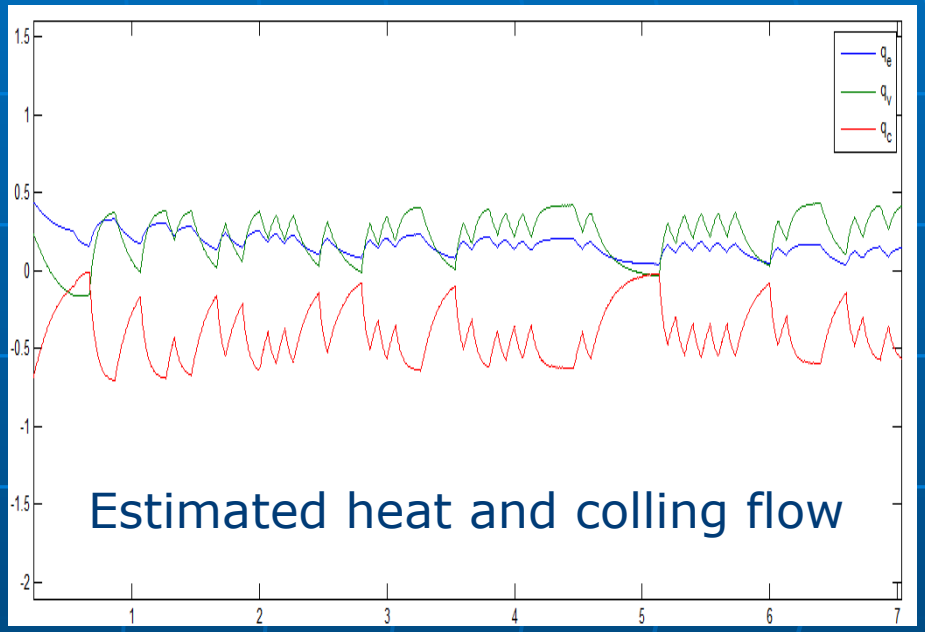
LARA - First-Principles Identification

Estimated Temperature parameters

I	e	v	c
a_i	220	321.3	175.4
K_i	0.035	0.095	0.241



Measured identification data



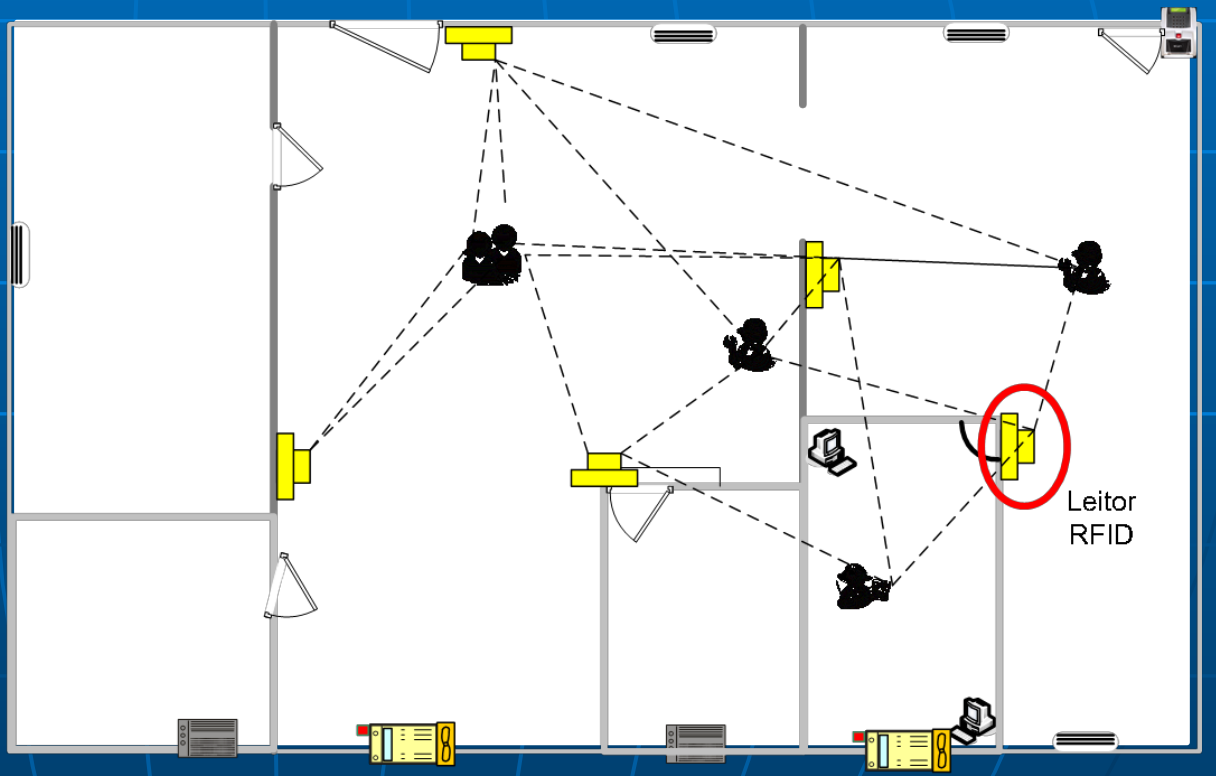
Estimated heat and colling flow

(Flávio Oliveira, 2010)
(Pedro Vianna, 2013)

Estimated humidity parameters

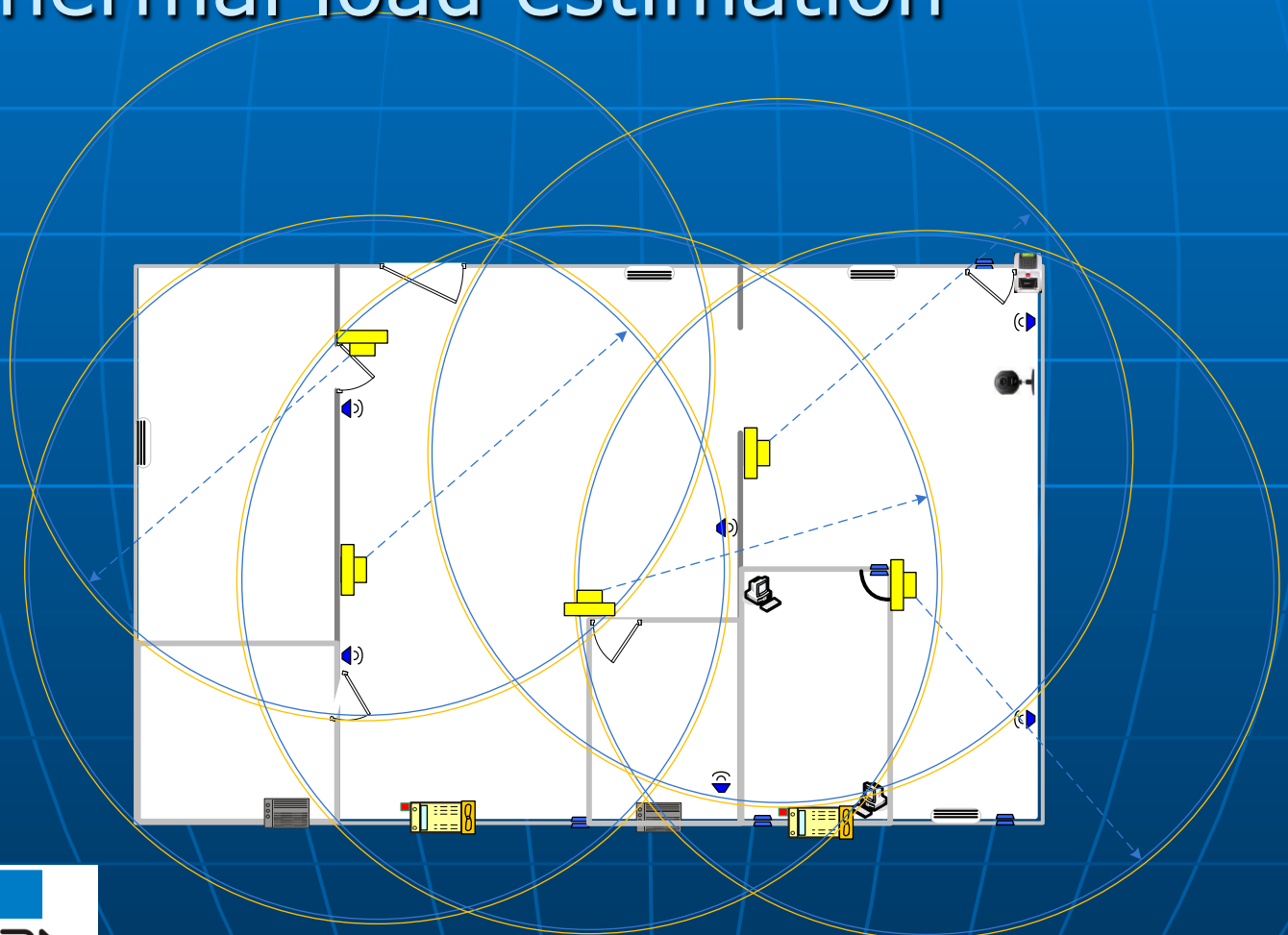
i	*u*	*uv*	*ue*	*um*	*s*
ai	168,5	164,9	80,82	171,7	-
Ki	2,19	3,77	0,151	-0,003	0,029

RFID occupancy identification (GPS indoor) for thermal load estimation

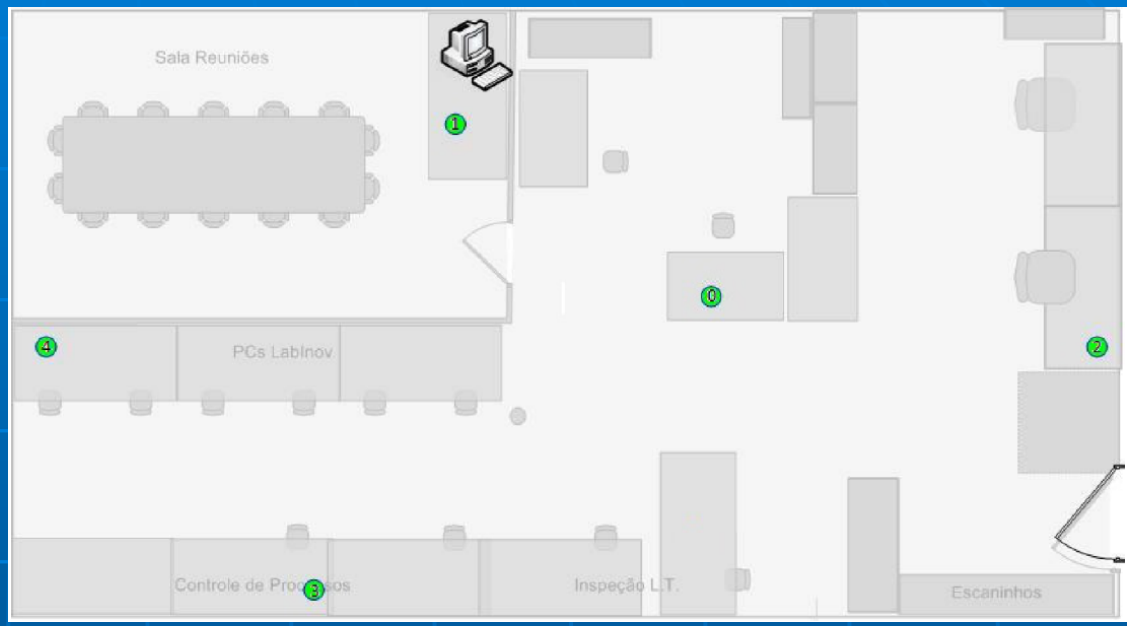


RFID occupancy identification

for thermal load estimation

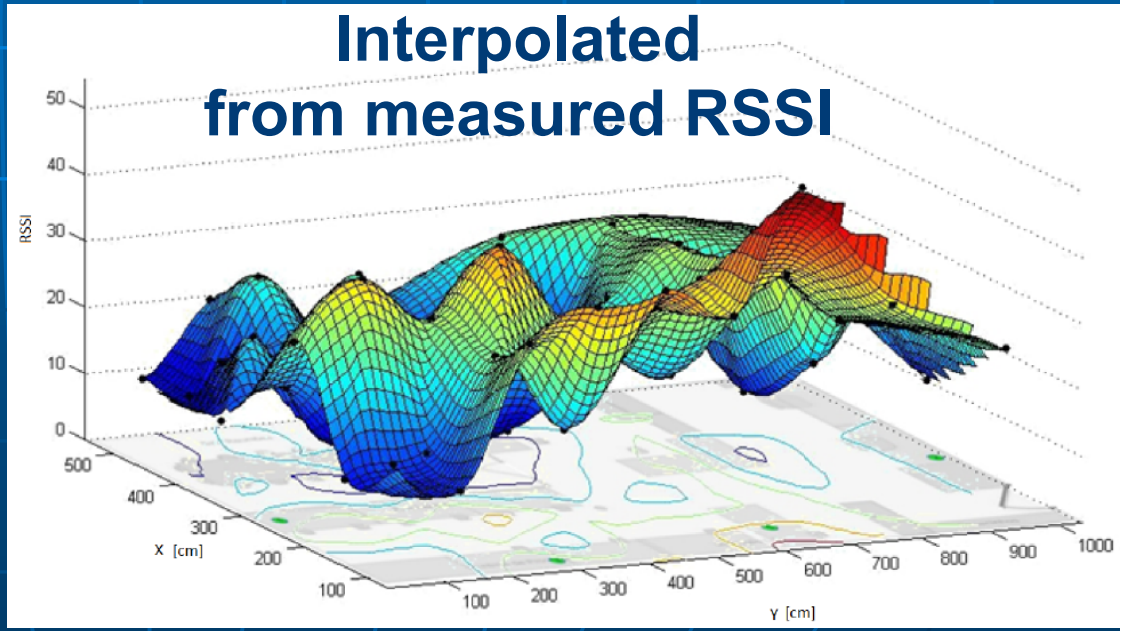


RFID occupancy identification for thermal load estimation



(Lucas Fonseca, 2011)

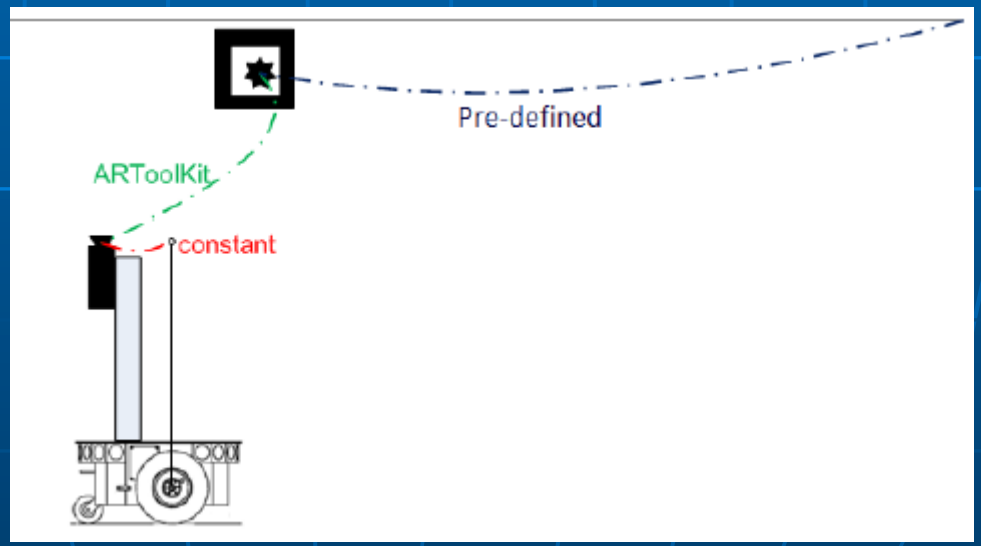
Interpolated from measured RSSI



Indoor RFID Localization

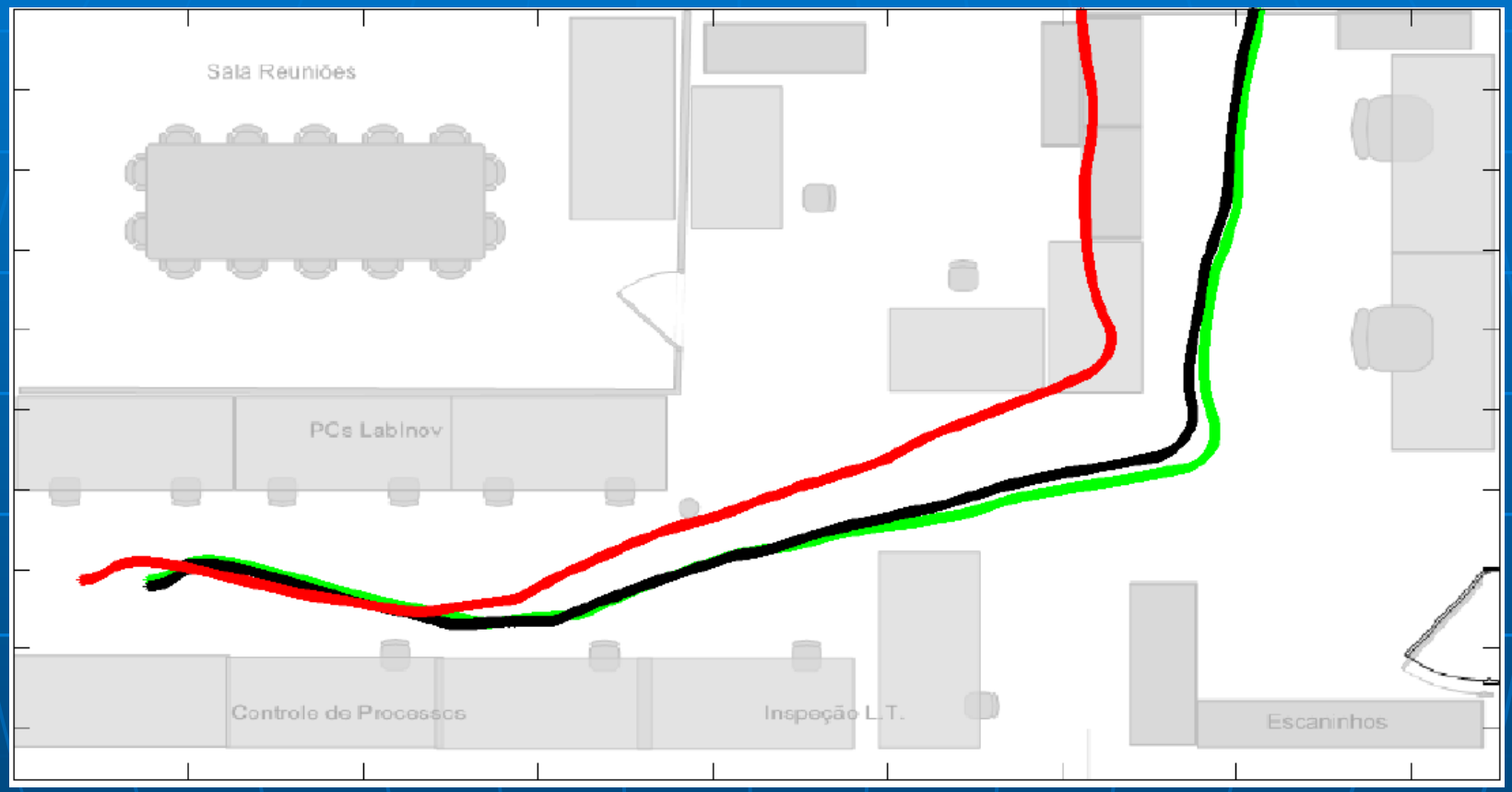
in the Context of Mobile Robotics with Application in Ambient Intelligence

Augmented Reality Localization



(Gabriel Figueiró e André Luiz Gama, 2011)

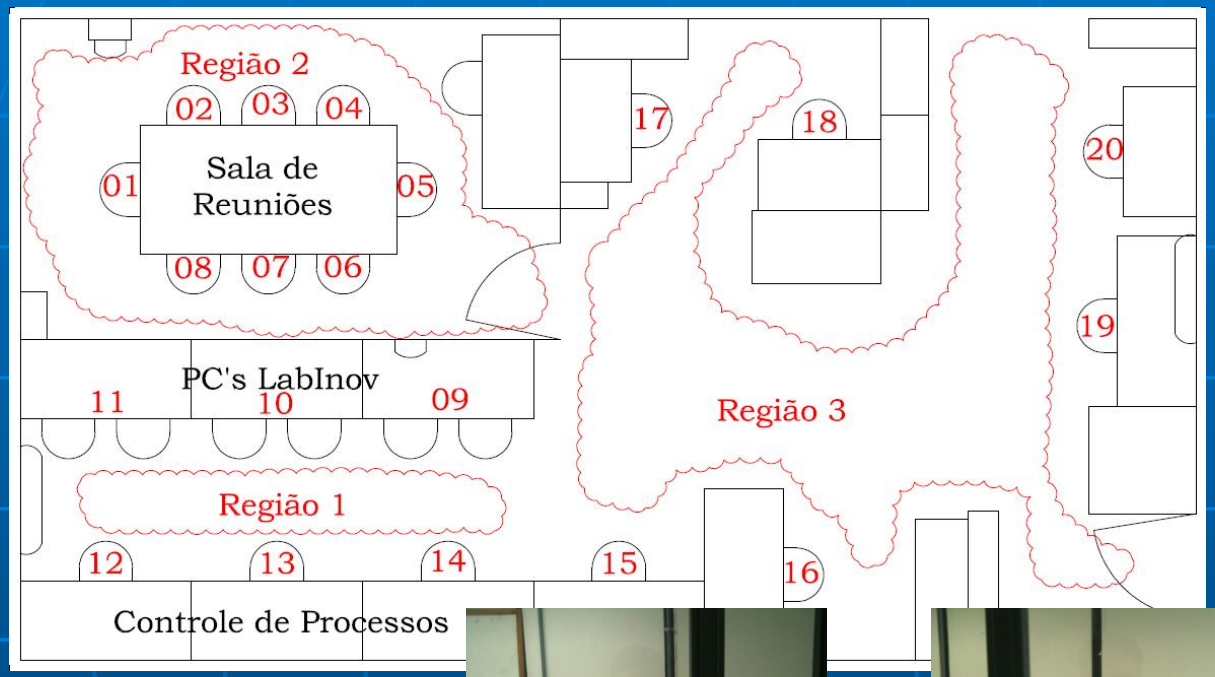
Comparison (Red – odo., Black – odo+vision, Green – all 3)



comparative results of the Augmented Reality-RFID RSSI system, Augmented reality system and pure odometry system

(Gabriel Figueiró e André Luiz Gama, 2011)

Thermal Load influence Areas



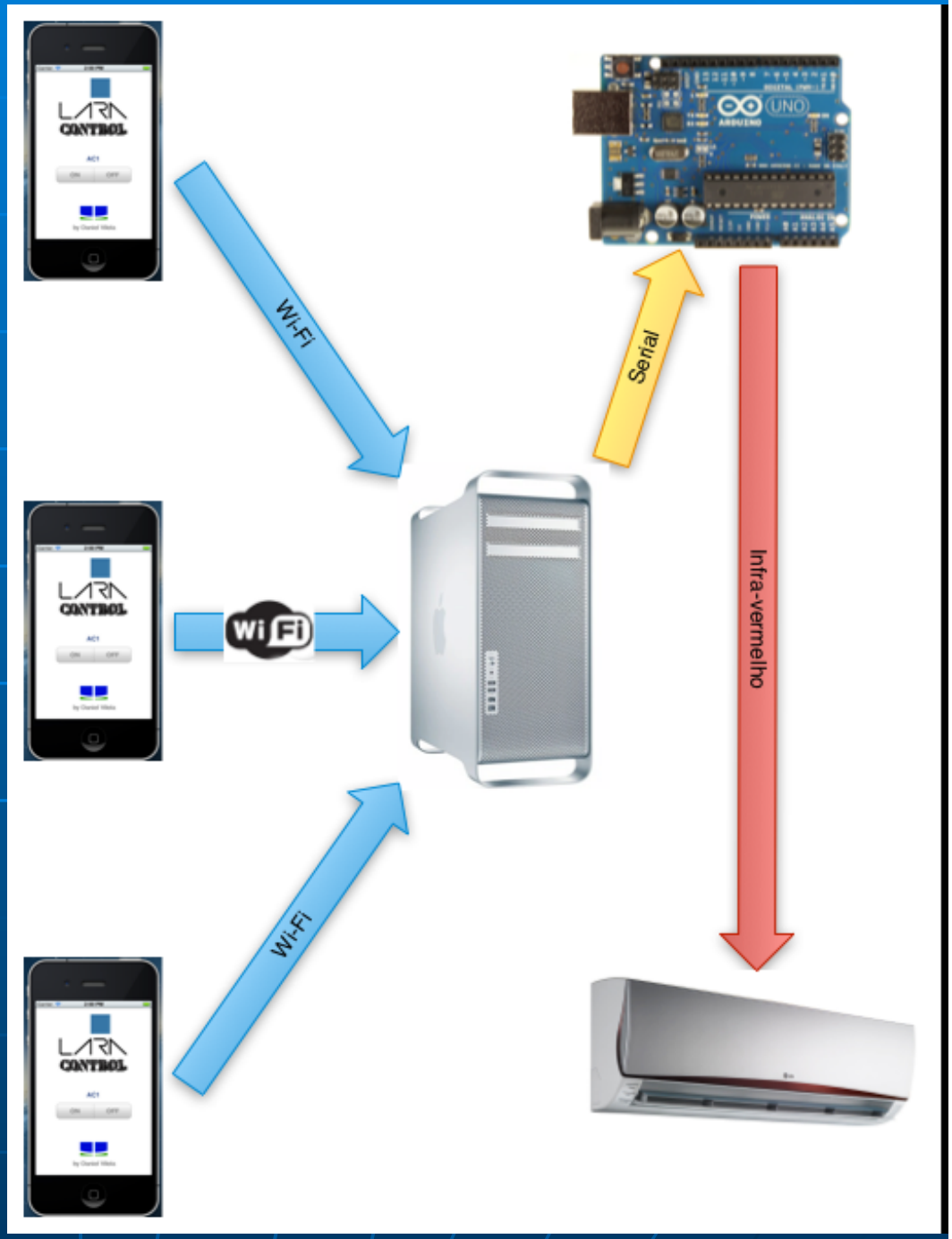
Identification of users in areas by RFID – RSSI classificators

(Cristovam Silva Jr., 2012)

Building Automation

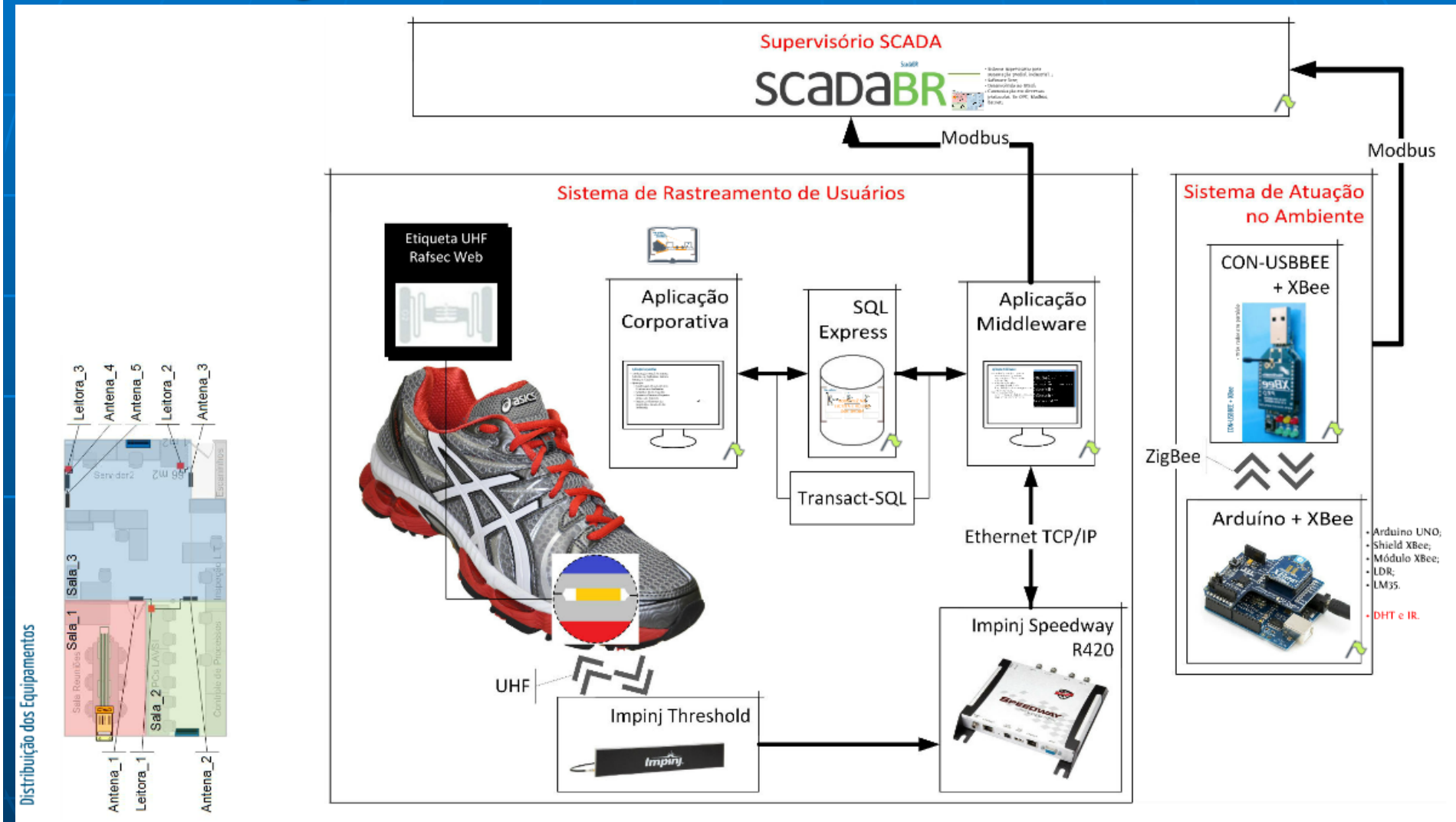
iPhone
WiFi
Arduino
ZigBee
Infra-Red
Air Conditioner

(Daniel Vilela, 2012)



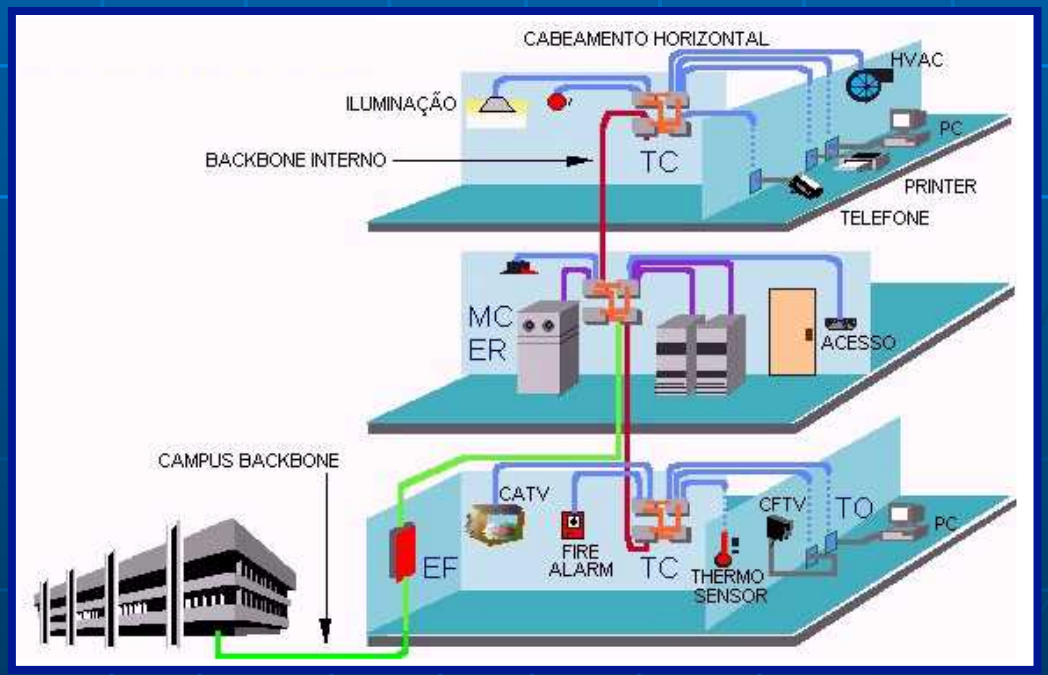
Passive RFID to track users

in building automation (Frederico Rocha e Filipe Oliveira, 2013)



Perspectives

- Energy Efficiency Labeling of Buildings
- nearly Zero Energy Building
- Assisted Living
- Virtual Campus
- Ambient Intelligence



Thank You!

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bauchspiess@lara.unb.br