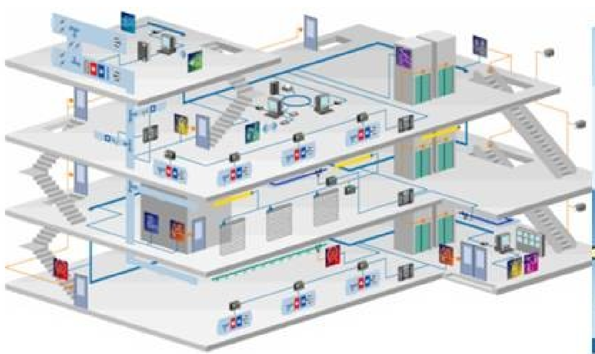
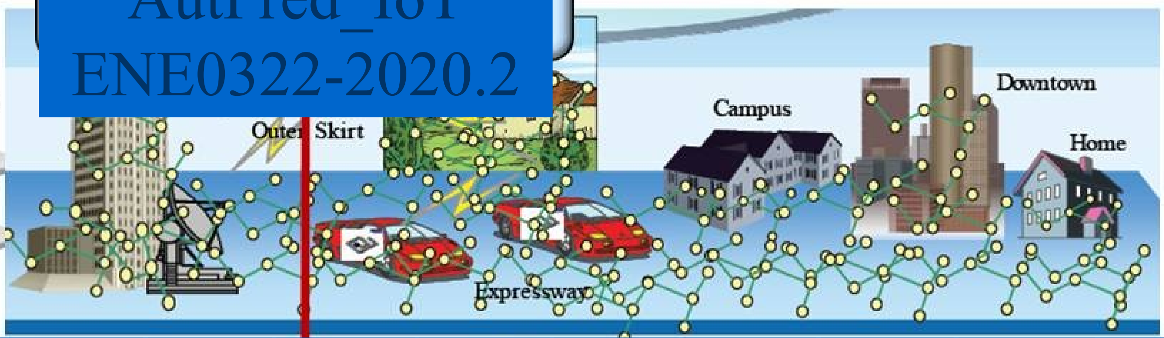
AutPred_IoT
ENE0322-2020.2





- Intelligent Building Automation -

"the search for the ZEB"

Prof. Adolfo Bauchspiess

LARA- Automation and Robotics Laboratory
Departamento de Engenharia Elétrica
Universidade de Brasília - Brazil

Summary

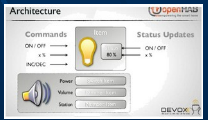
Concepts:

- Sub-systems
- Segments
- Technologies
- Where can you work?
- Ambient Intelligence

Some Research Projects

- Energy Saving
- Thermal Comfort
- User tracking
- nZEB

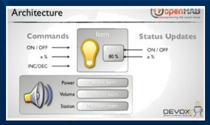
Perspectives



Intelligent Building Automation

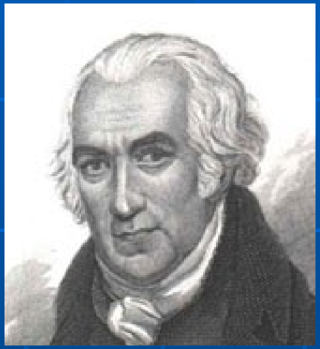
#trend_topics

- *Building Automation*
- *Artificial Intelligence*
- *Ambient Intelligence*
- *Ubiquitous Systems*
- *Assisted Living*
- *Cyber Physical Systems*
- *nZEB*
- ***Smart*** *Environments / Buildings / Campus / Cities*

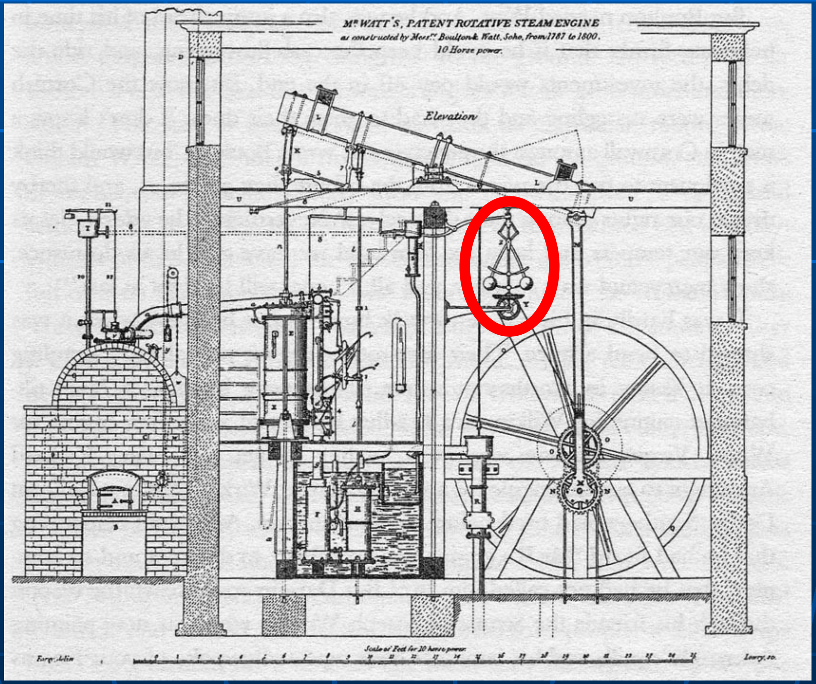


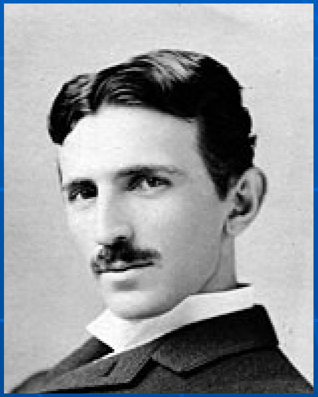
Automation – The Beginning

Flour mill
Work of 10 men
Xth century

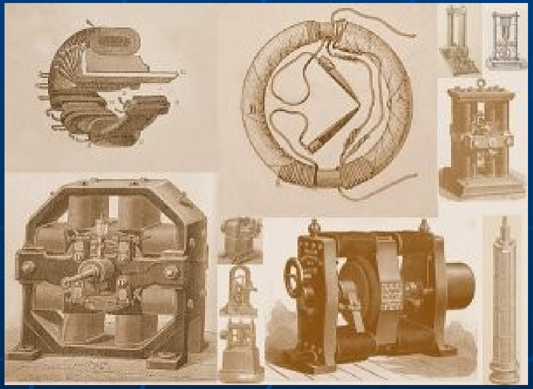


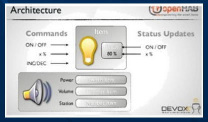
James Watt -1775
Steam Engine
Flyball governor





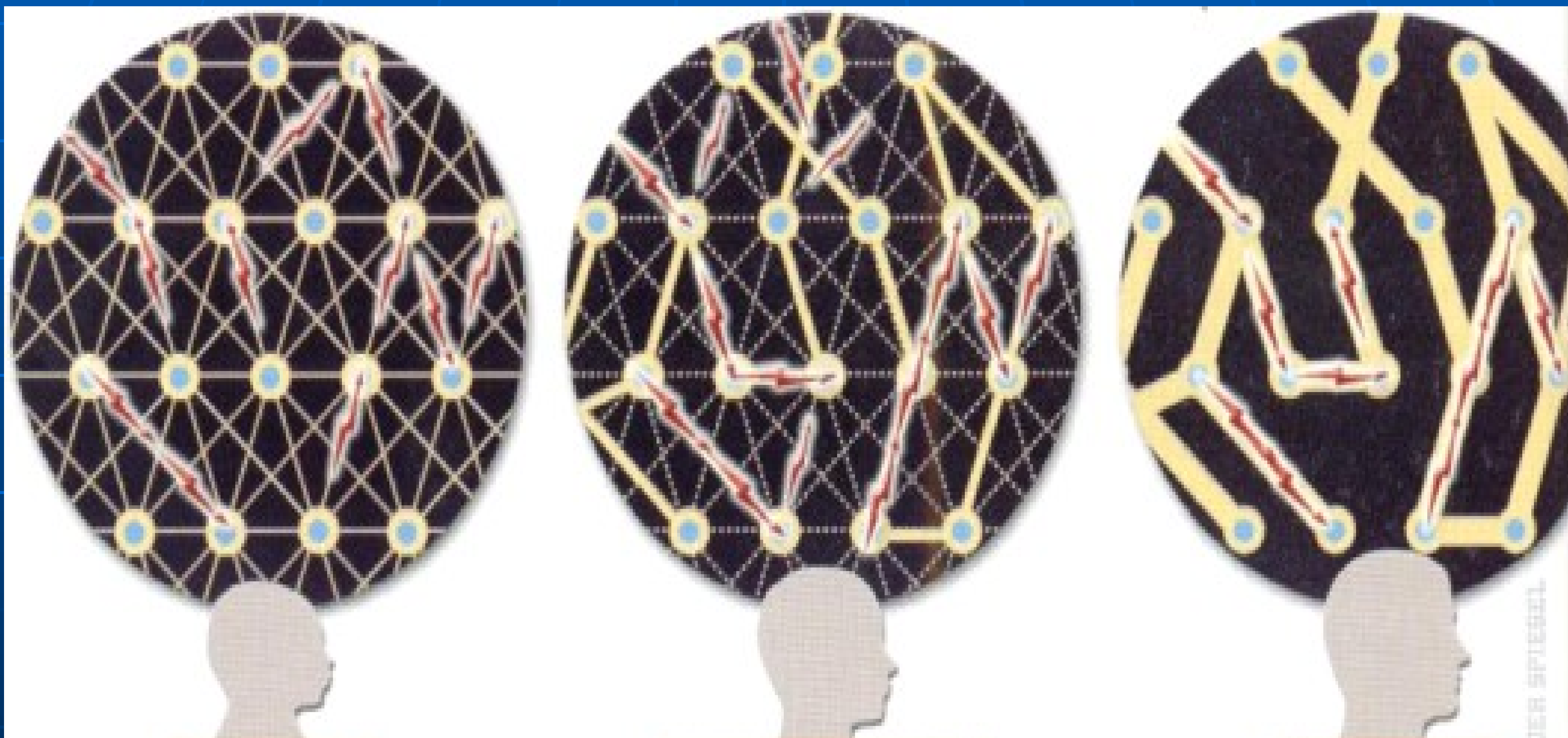
Tesla (⋆1856 †1943)
Multiphase Systems
AC Motor





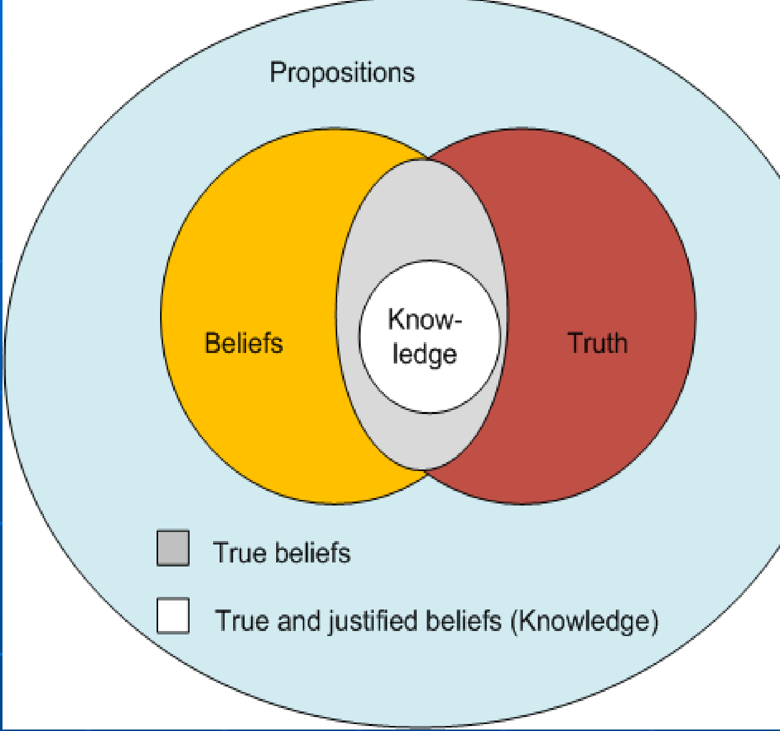
Intelligent Systems - The Brain as model !!

Build Neuron Synaptic *Connections* - Learning!

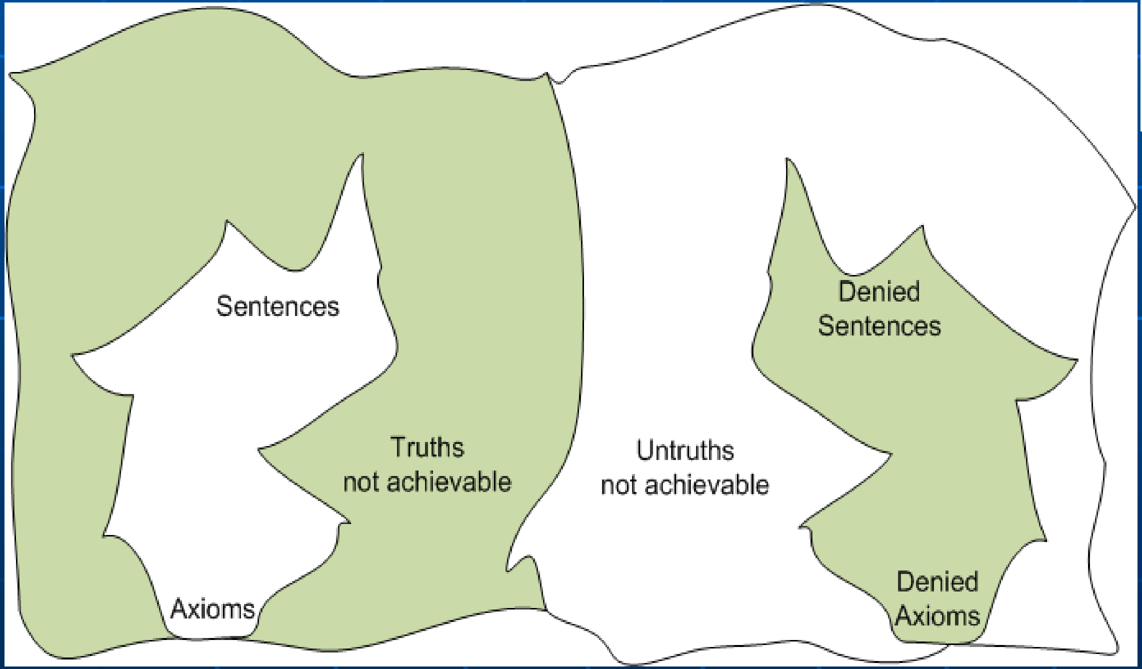


0-2 years | 2 years to puberty | Adult

“Philosophy of Knowledge”



[Gödel's incompleteness theorems, 1931]()



“Heuristics”
A way that works,
but you do not know way.

“Sub-optimal solutions”
The brain is ***expert*** in finding good heuristics!

Artificial Intelligence?

From Natural Intelligence to Artificial Intelligence

Ex. – Dislexia?

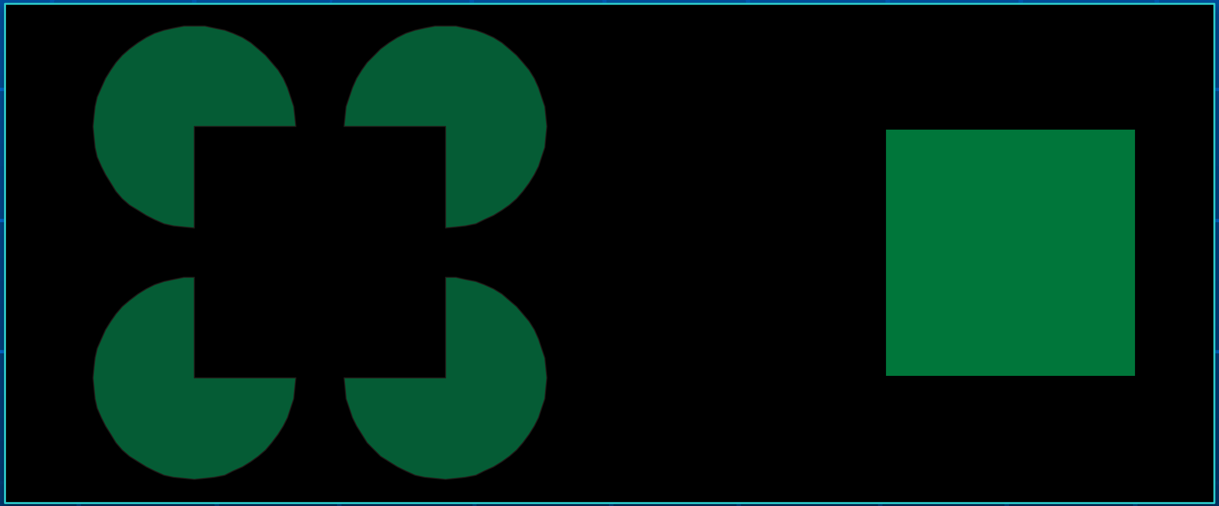
I cnduo't bvleiee taht I culod aulaclty uesdtannrd waht I was rdnaieg. Unisg the icndeblire pweor of the hmuan mnid, aocdcrnig to rseecrah at Cmabrigde Uinervtisy, it dseno't mttaer in waht oderr the lterets in a wrod are, the olny irpoamtnt tihng is taht the frsit and lsat ltteer be in the rhgit pclae. The rset can be a taotl mses and you can sitll raed it whoutit a pboerlm. Tihs is bucseae the huamn mnid deos not raed ervey ltteer by istlef, but the wrod as a wlohe. Aaznmig, huh? Yaeh and I awlyas tghhuot slelinpg was ipmorantt! See if yuor fdreins can raed tihs too.

- Incomplete pattern -

Brain

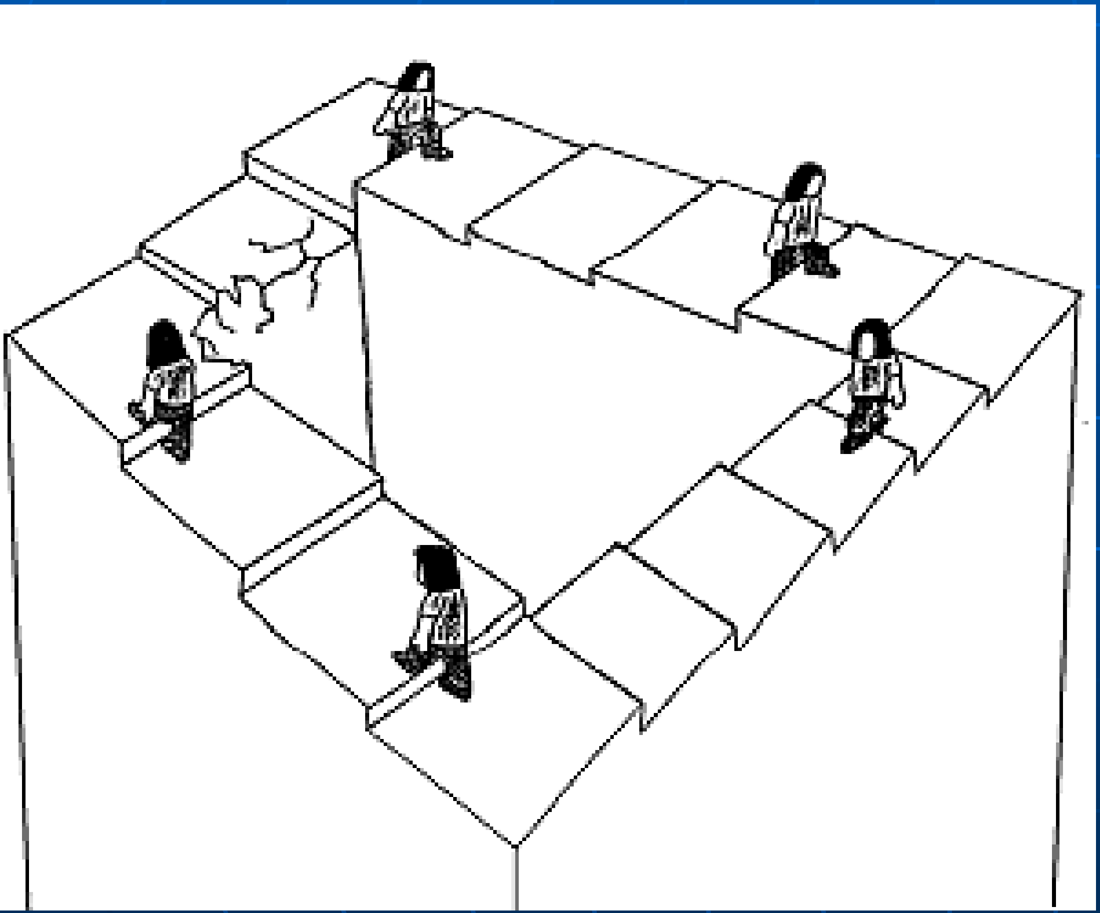
Interpolation!

-Perception



The Kanizsa square, 1976

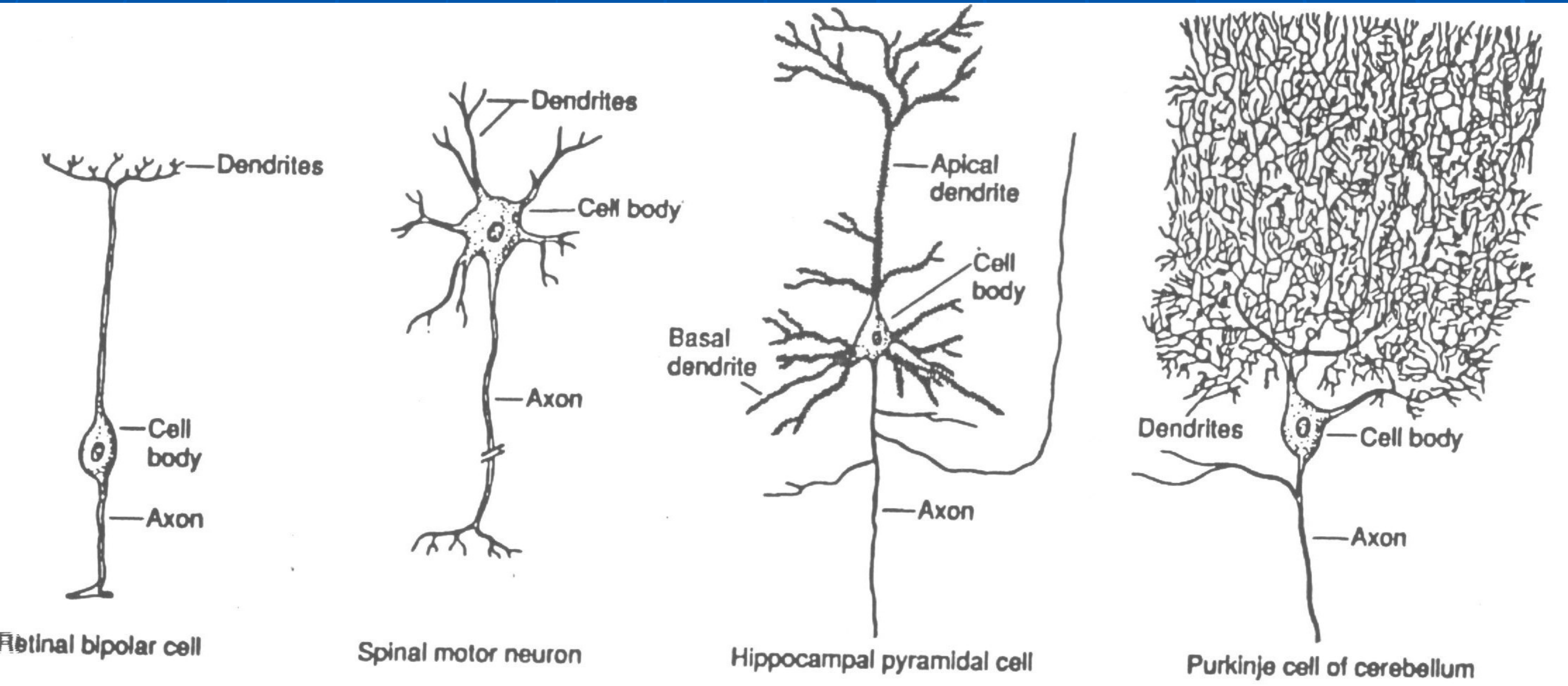
“Local Coherency –Global Paradox"



Sandro delPrete. Enigmas Visuais. Rio de Janeiro, 2004, p. 45

Biological Fundaments

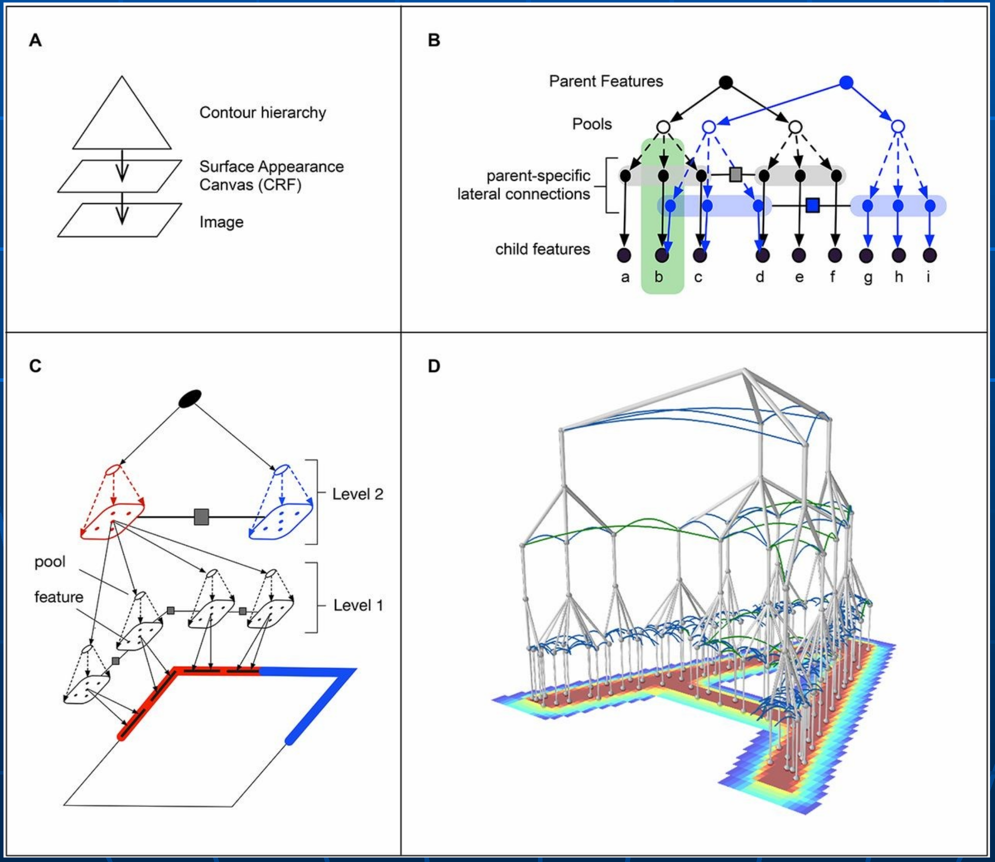
Some kinds of neurons



Cortical Recurrent Networks

A generative vision model that trains with high data efficiency and breaks text-based CAPTCHAs

D. George, W. Lehrach, K. Kansky, M. Lázaro-Gredilla, C. Laan, B. Marthi, X. Lou, Z. Meng, Y. Liu, H. Wang, A. Lavin, D. S. Phoenix
Science Vol.: eaag2612 DOI: 10.1126/science.aag2612

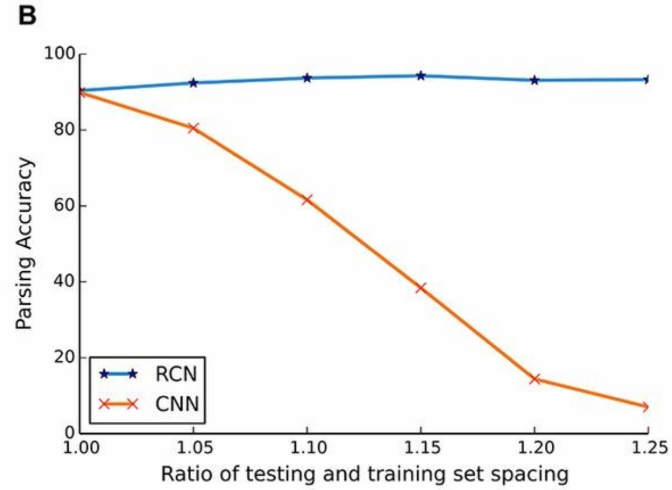


CAPTCHA - CRN

A

Input & Ground Truth	RCN Top Parse	RCN Second Parse	Human Labels
calwlme	calwime	calwlme	canmme caiwime
erldhhm	erldbhm	erldhhm	erldnhm erldhhm
esterrow	esterrow	estenow	esterrow esterrow

B



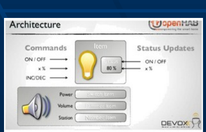
C

CAPTCHA name	Examples	Word Accuracy	Character Accuracy
reCAPTCHA		66.6%	94.3%
Botdetect		64.4%	91.6%
Yahoo		57.4%	92.5%
PayPal		57.1%	89.3%

D

Living connected

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



Ambient Ingelligence

"Provide services to the users of an ambient through an almost invisible wireless sensor and actuator network"

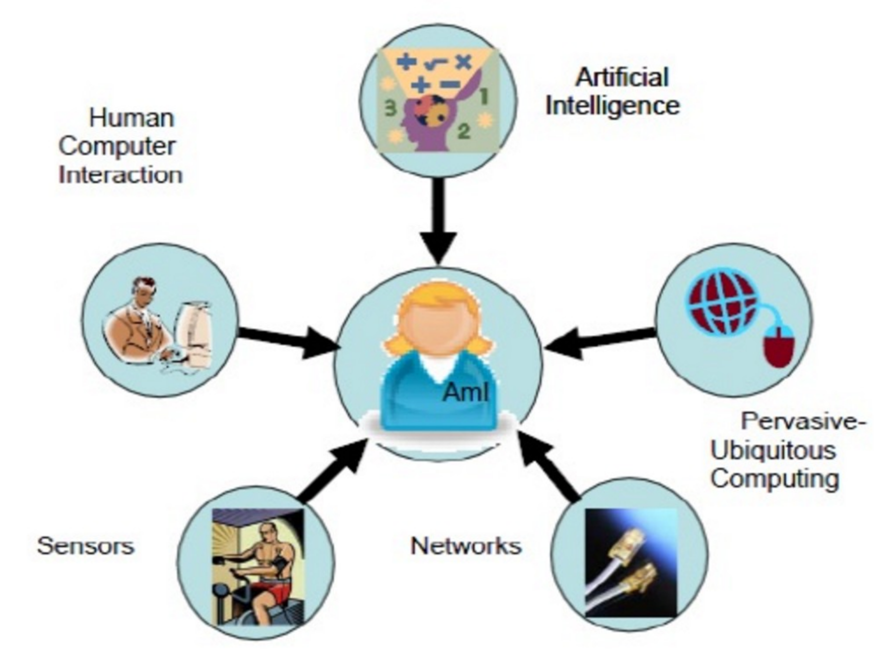
Summary

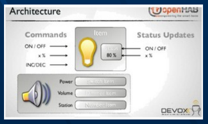
1 – Concepts

2 – Projects

- Energy saving
- Comfort
- User Tracking

3 – Perspectives





Building Automation - Segments

- ✓ Schools
- ✓ Hospitals
- ✓ Hotels
- ✓ Pharmaceutical
- ✓ Commercial
- ✓ Airports
- ✓ Stadiums
- ✓ Domotics
- ✓ …

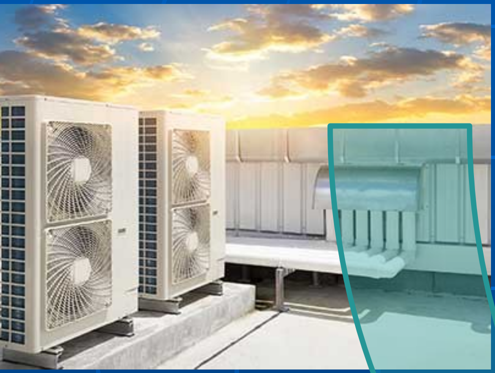








Sub-Systems



- ✓ HVAC
- ✓ Illumination
- ✓ Fire
- ✓ Energy Management
- ✓ Back-Up Power Gen.
- ✓ CC-TV
- ✓ Access Control
- ✓ Elevator/Escalator
- ✓ …

Building Automation- **Objectives**

- Security
  - Access Control
  - CC-TV
- Fire Detection

- Comfort (Productivity)
- temperature, humidity,… (PMV)
- illumination,
  - waiting time for elevators, …

- Health issues
  - air quality (renovation, filters…)
  - CO_2

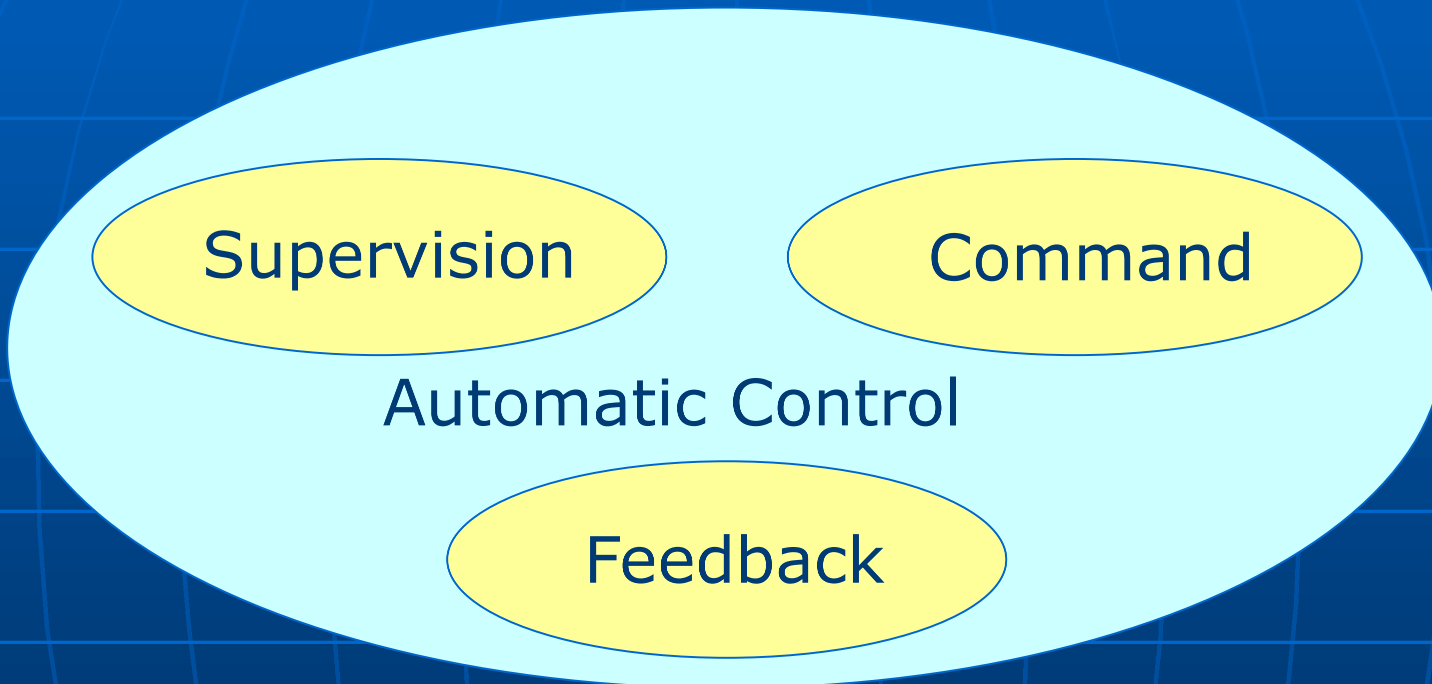
- Energy Saving

Building Automation- **Technologies**

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

- Network
  - Cabled
  - PLC
  - Wireless

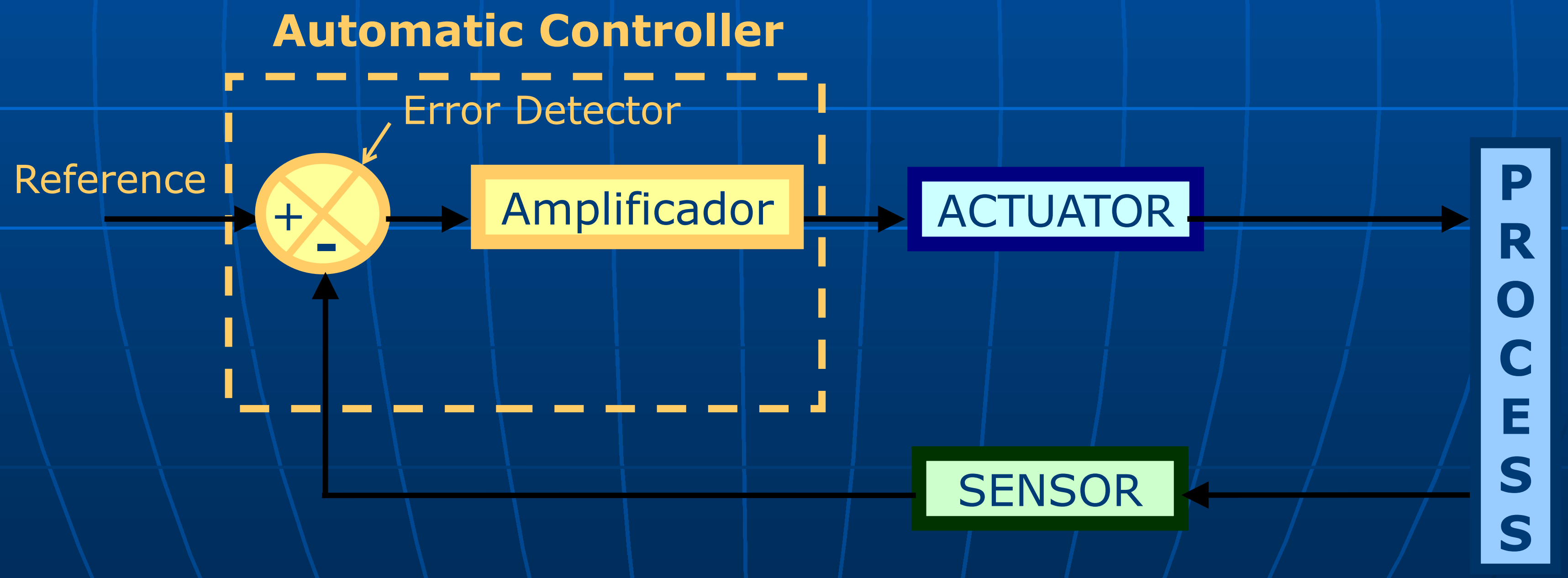
- Devices
  - Modularity (Easy to expand)
  - Interoperability


Supervision
Command
Automatic Control
Feedback

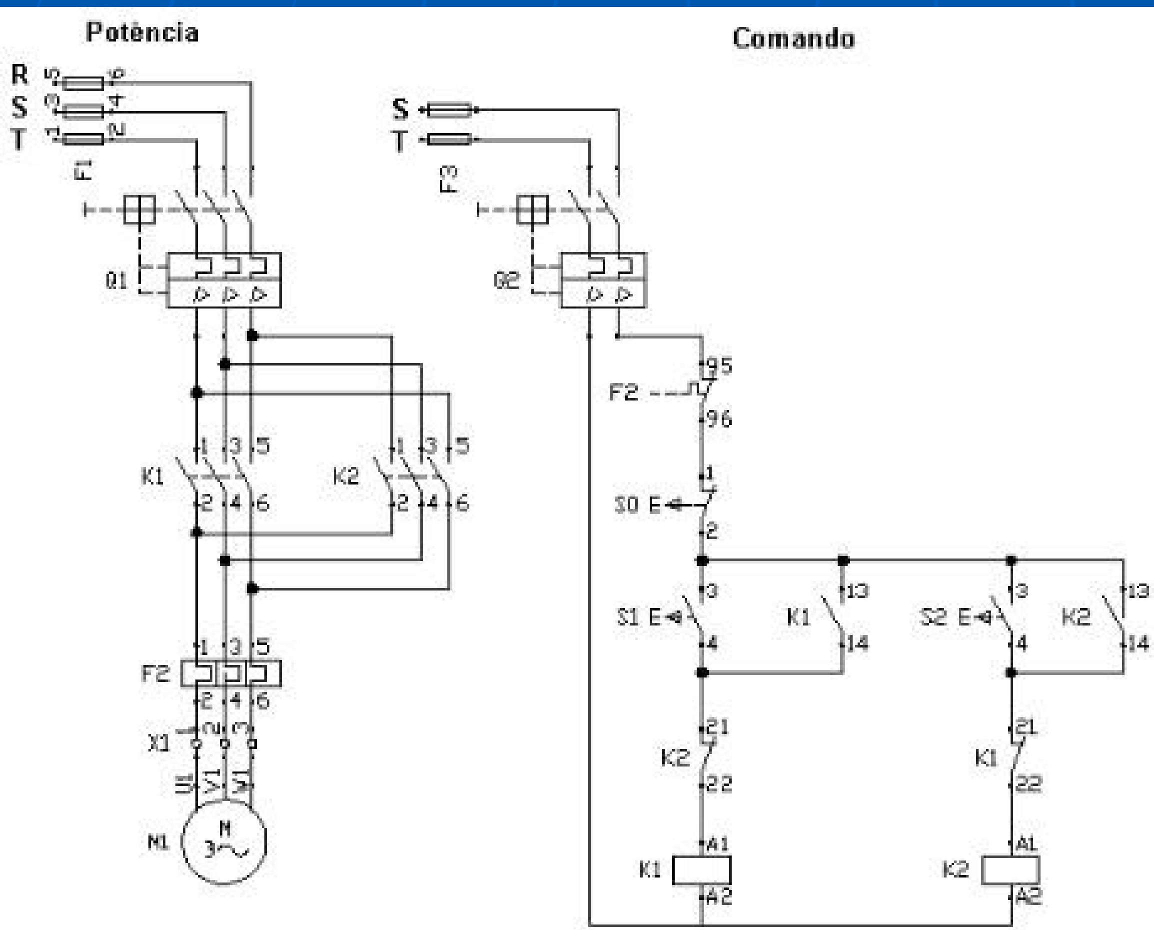
Automatic Control

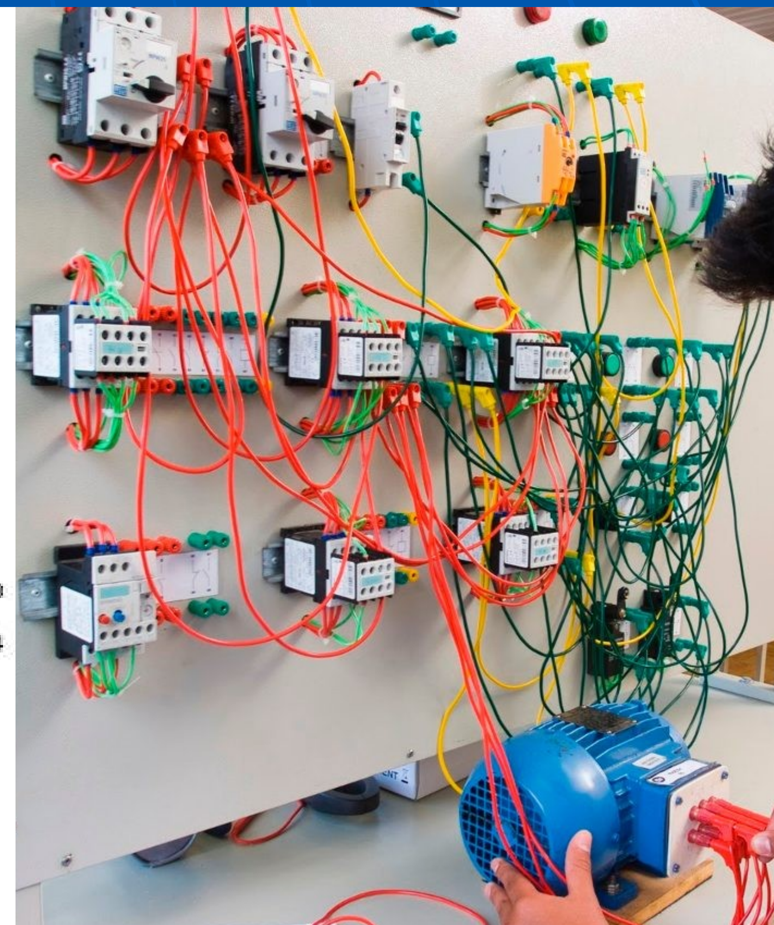
Keep a process variable at the reference value

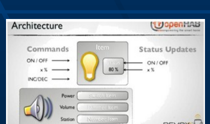
"Compare reference and measured value then act"



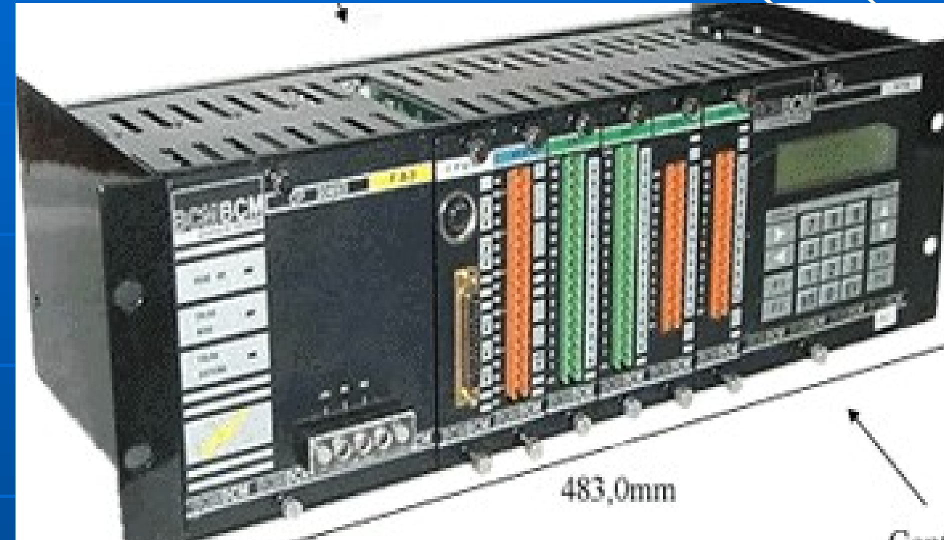
Relay-Logic


Potência
Comando
R
S
T
F1
Q1
K1
K2
F2
X1
U1
V1
W1
M1
M
3~
S
T
F3
Q2
F2
95
96
S0
S1
S2
13
14
21
22
A1
A2

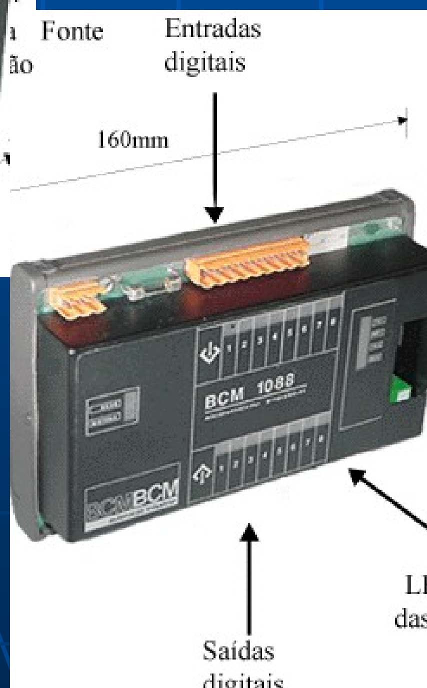


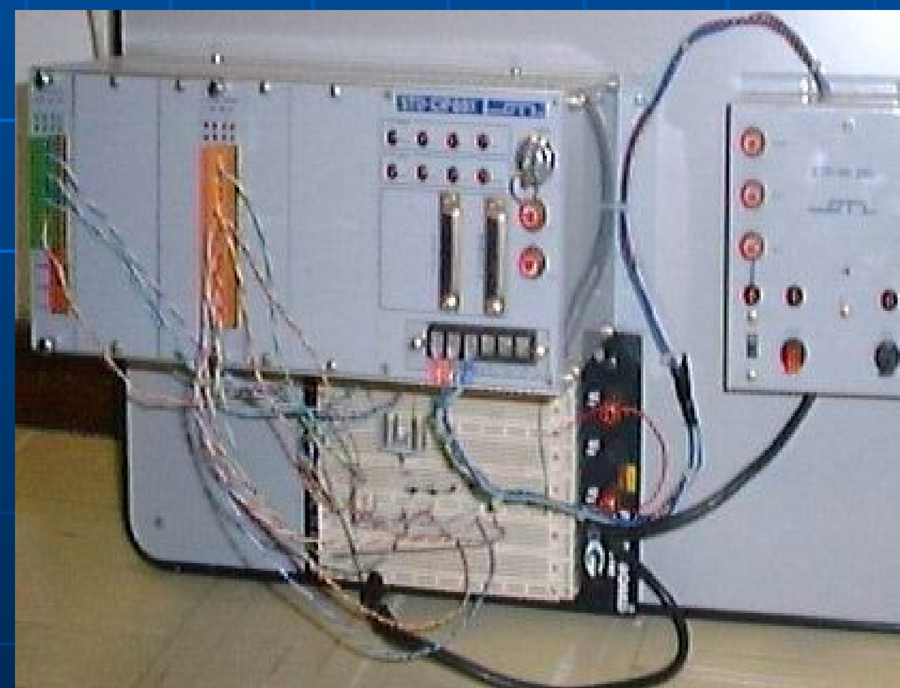


Some PLCs.br

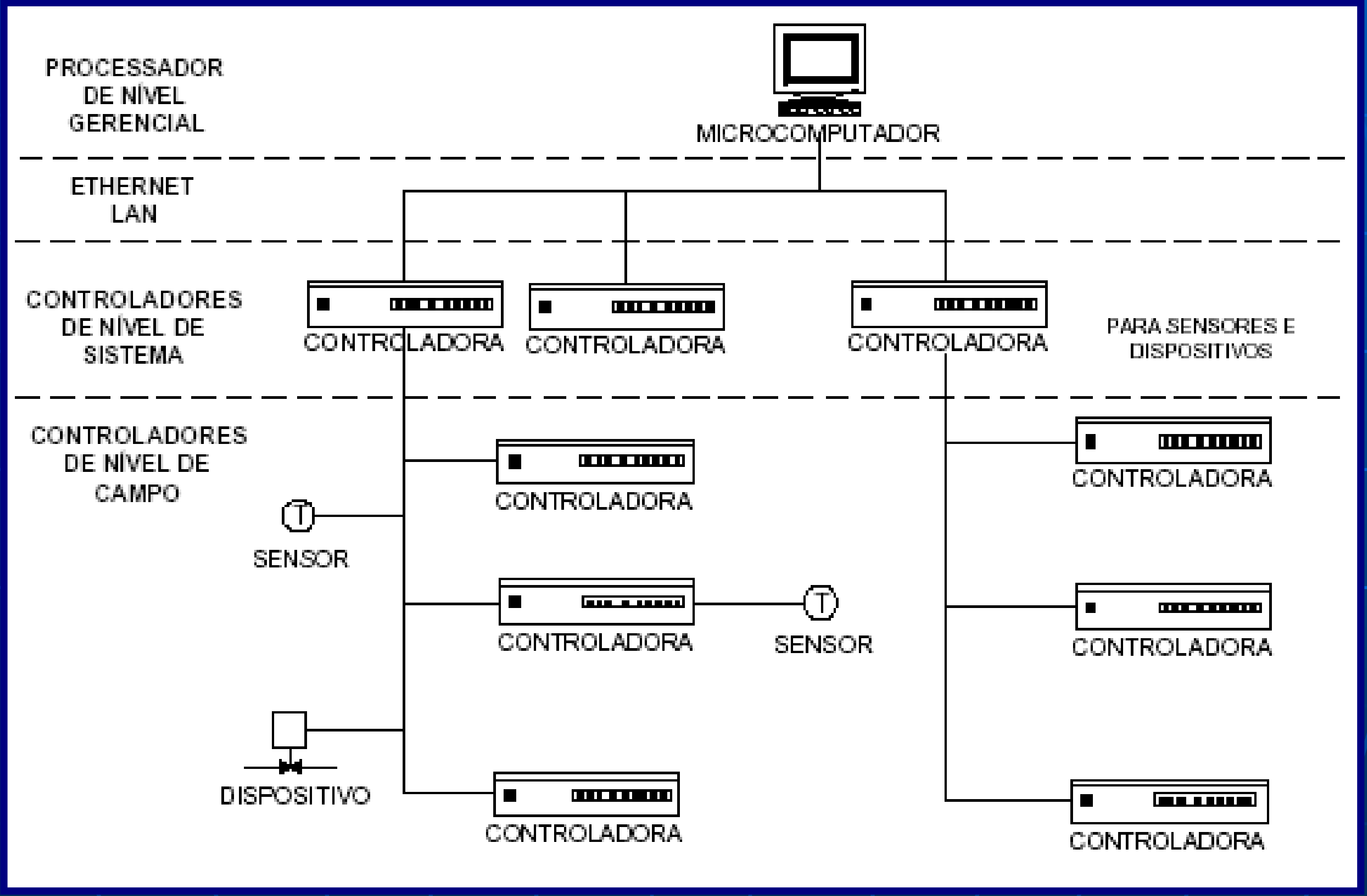

483,0mm

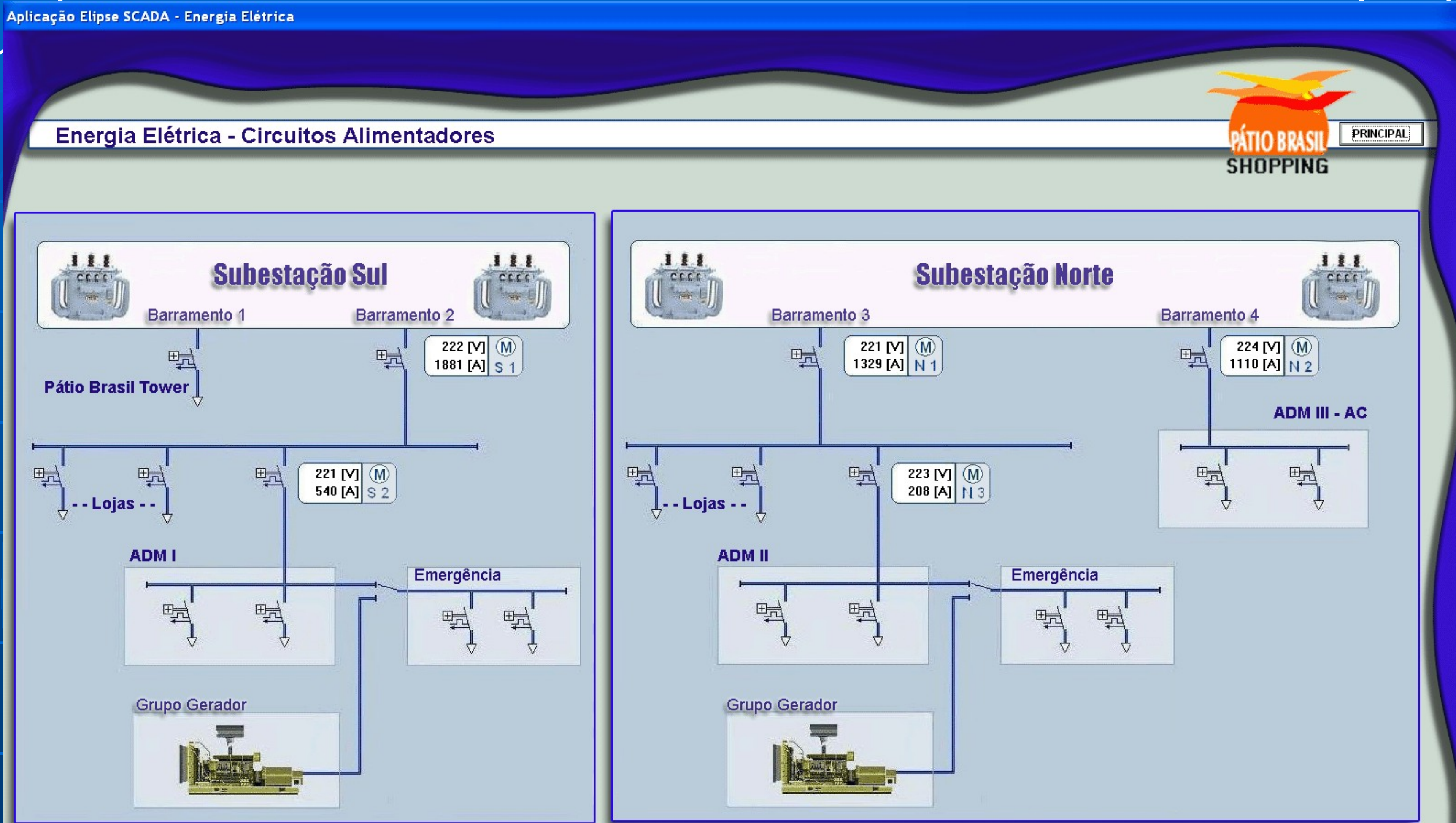

BCM BCM
180mm


Fonte
Entradas digitais
160mm
BCM 1088
BCM BCM
Saídas digitais



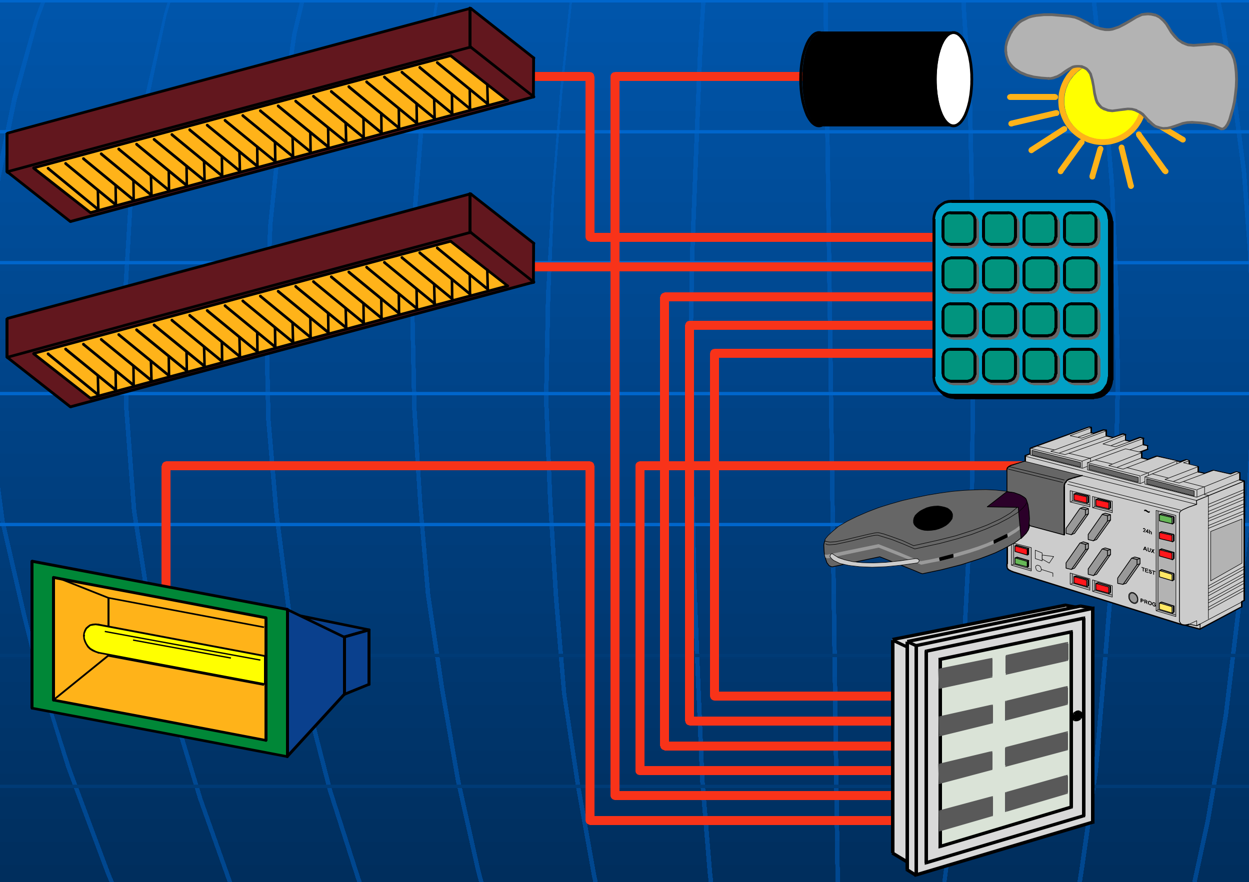
Automation System



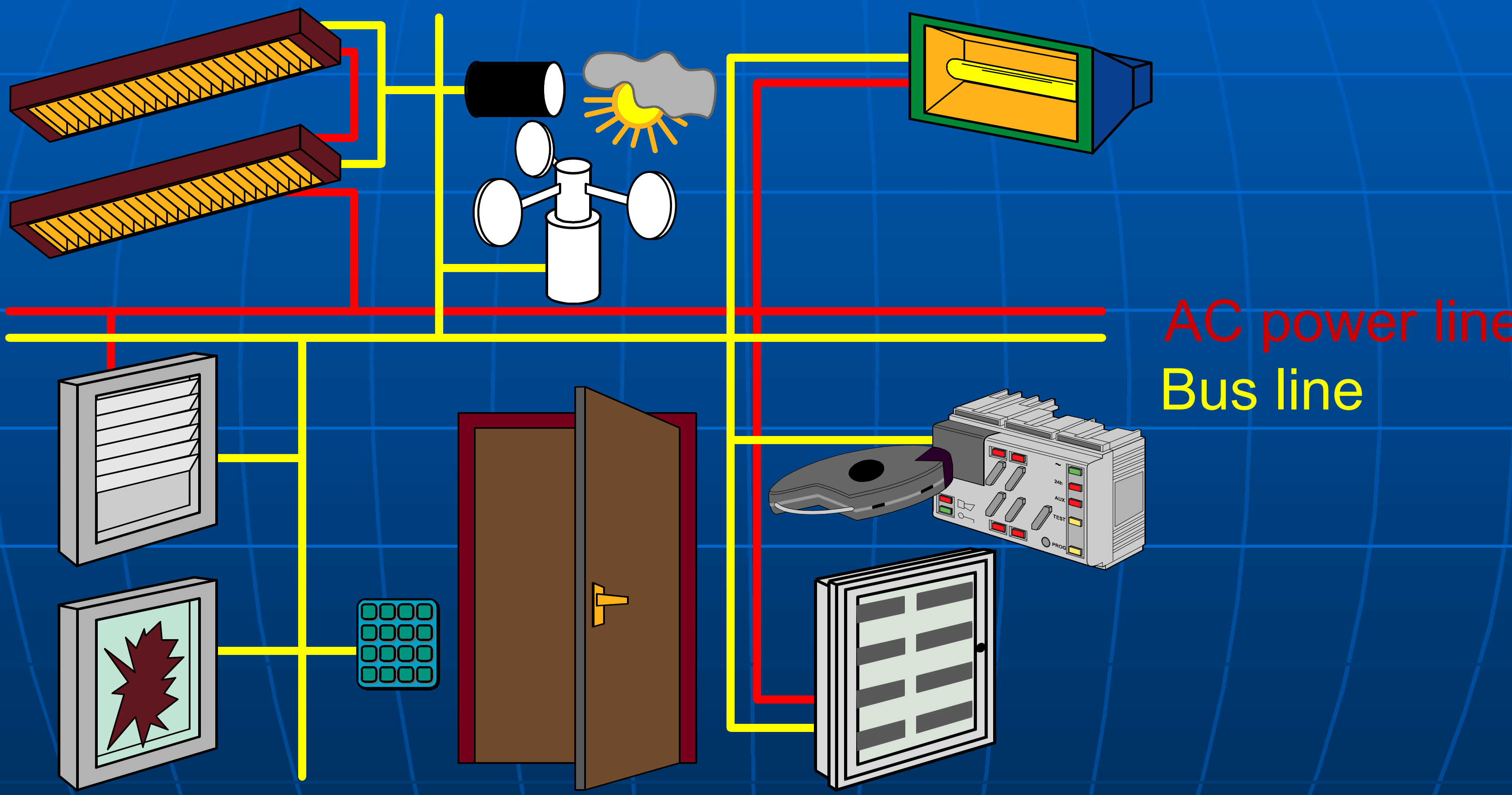


	Alimentador Sul - M S1				ADM I - Medidor M S2				Alimentador Norte - M N1				ADM II - Medidor M N3				ADM III (AC) - Medidor M N2			
	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]	[V]	[A]	FP	[kW]
FASE R	220	1930	0,89	378130	220	589	0,83	107742	220	1027	0,80	180481	221	211	0,95	44343	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

Traditional Connection

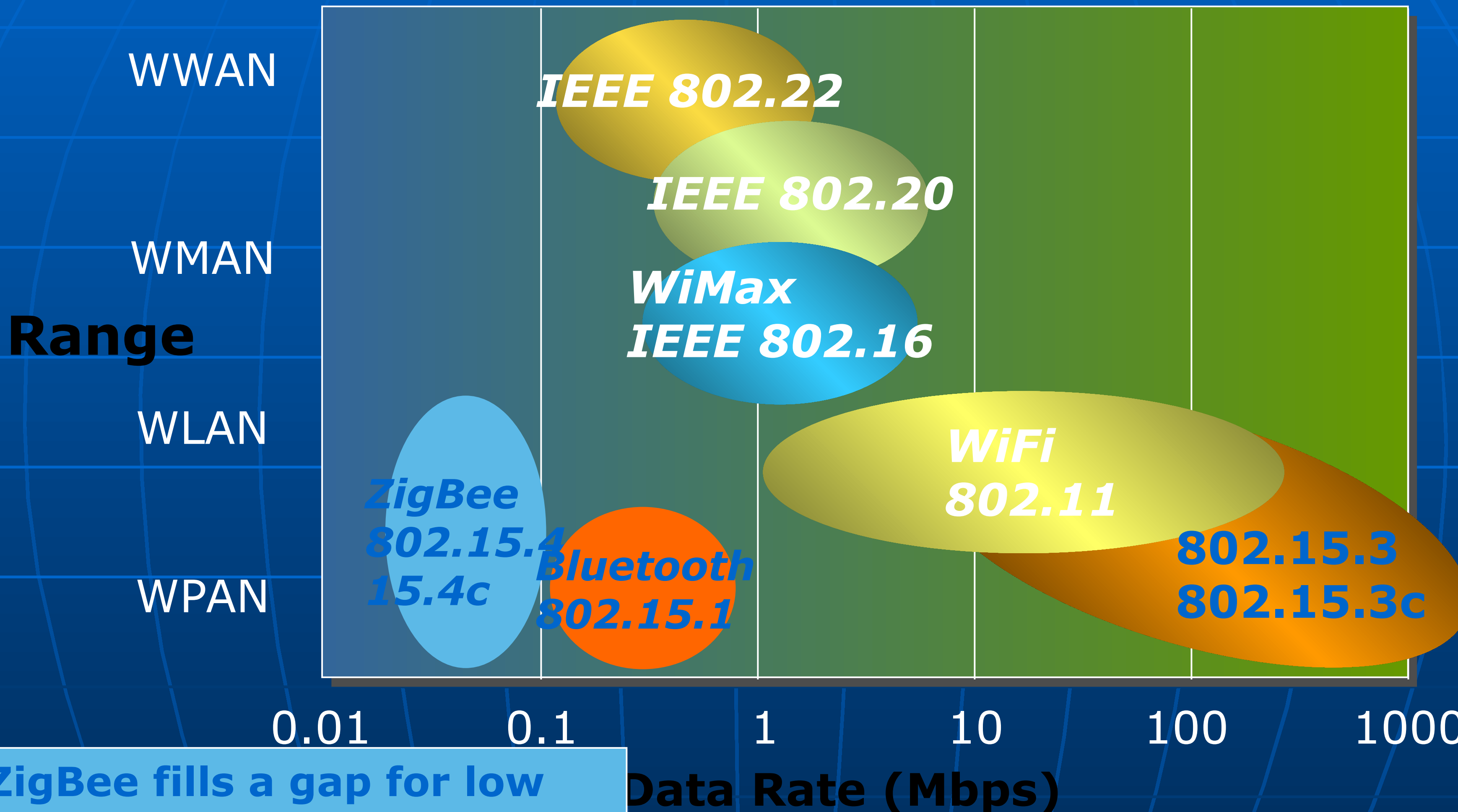


Bus Connection



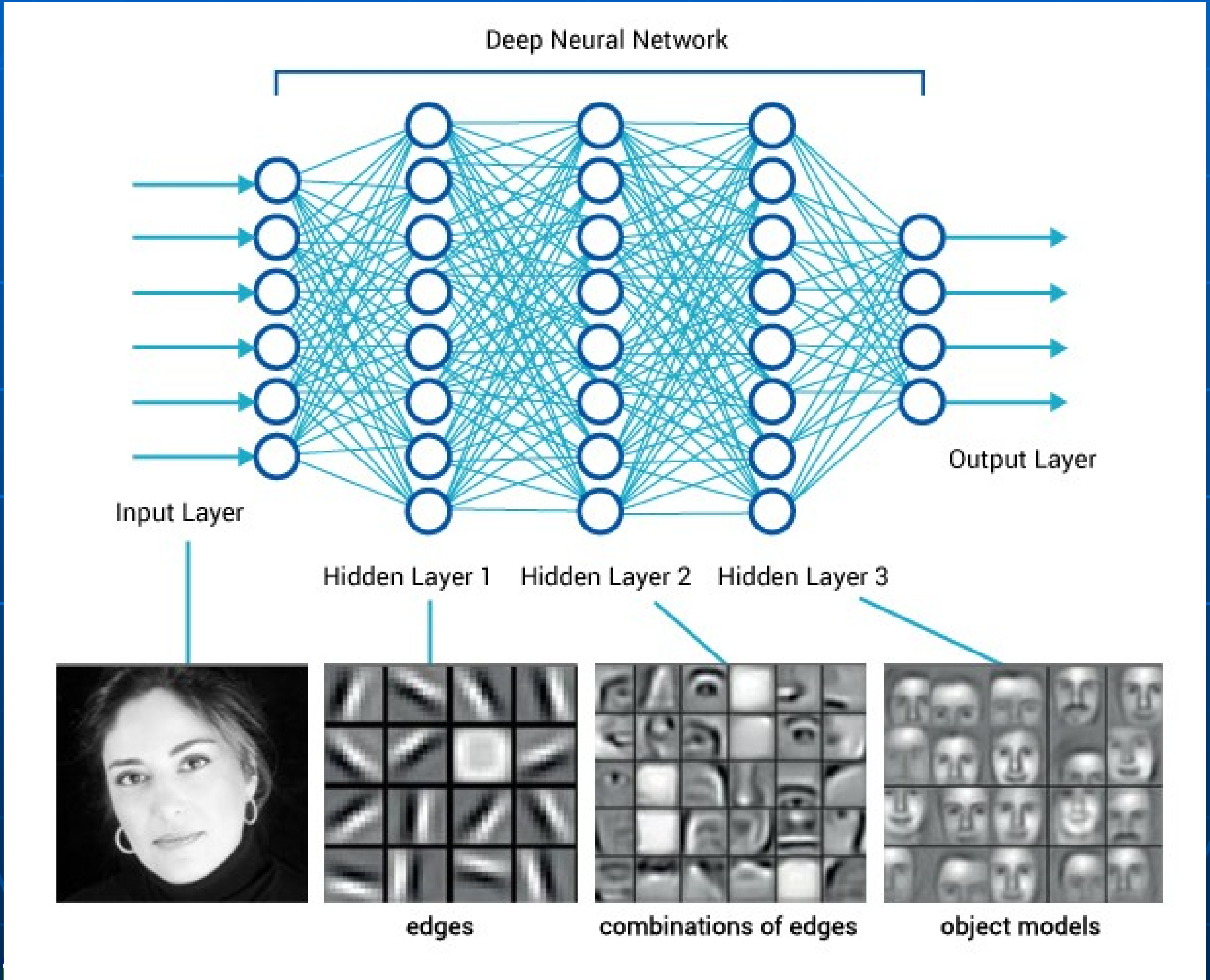
...wireless

The IEEE 802 Wireless Space



ZigBee fills a gap for low data rate applications

Deep Learning – Convolutional Networks



ZigBee Applications

BUILDING AUTOMATION

HVAC
AMR

CONSUMER ELECTRONICS

TV
VCR
DVD/CD
remote

PERSONAL HEALTH CARE

patient monitoring
fitness monitoring

PC & PERIPHERALS

mouse
keyboard
joystick

TELECOM SERVICES

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

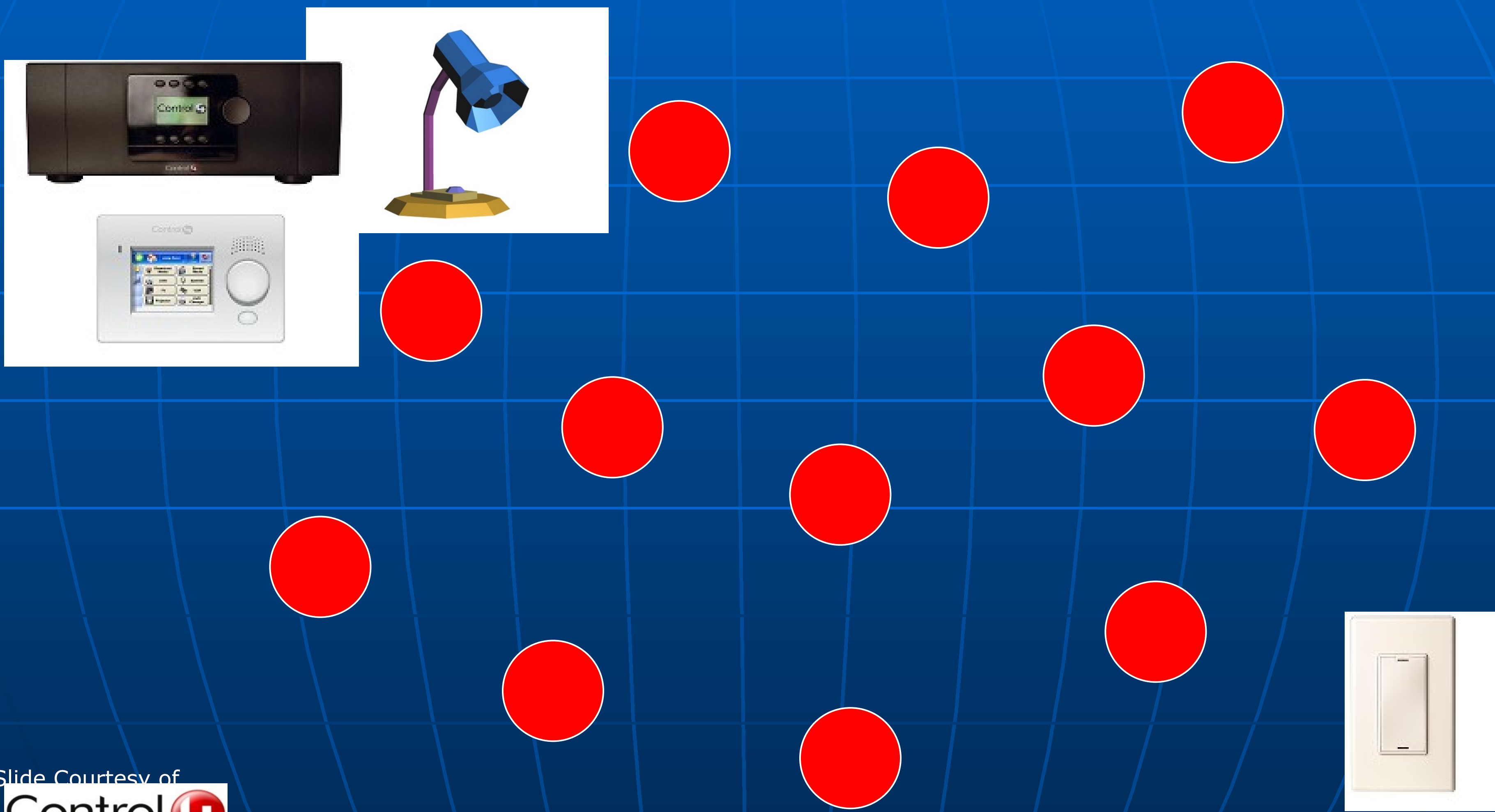
INDUSTRIAL CONTROL

asset mgt
process control
environmental
energy mgt

HOME CONTROL

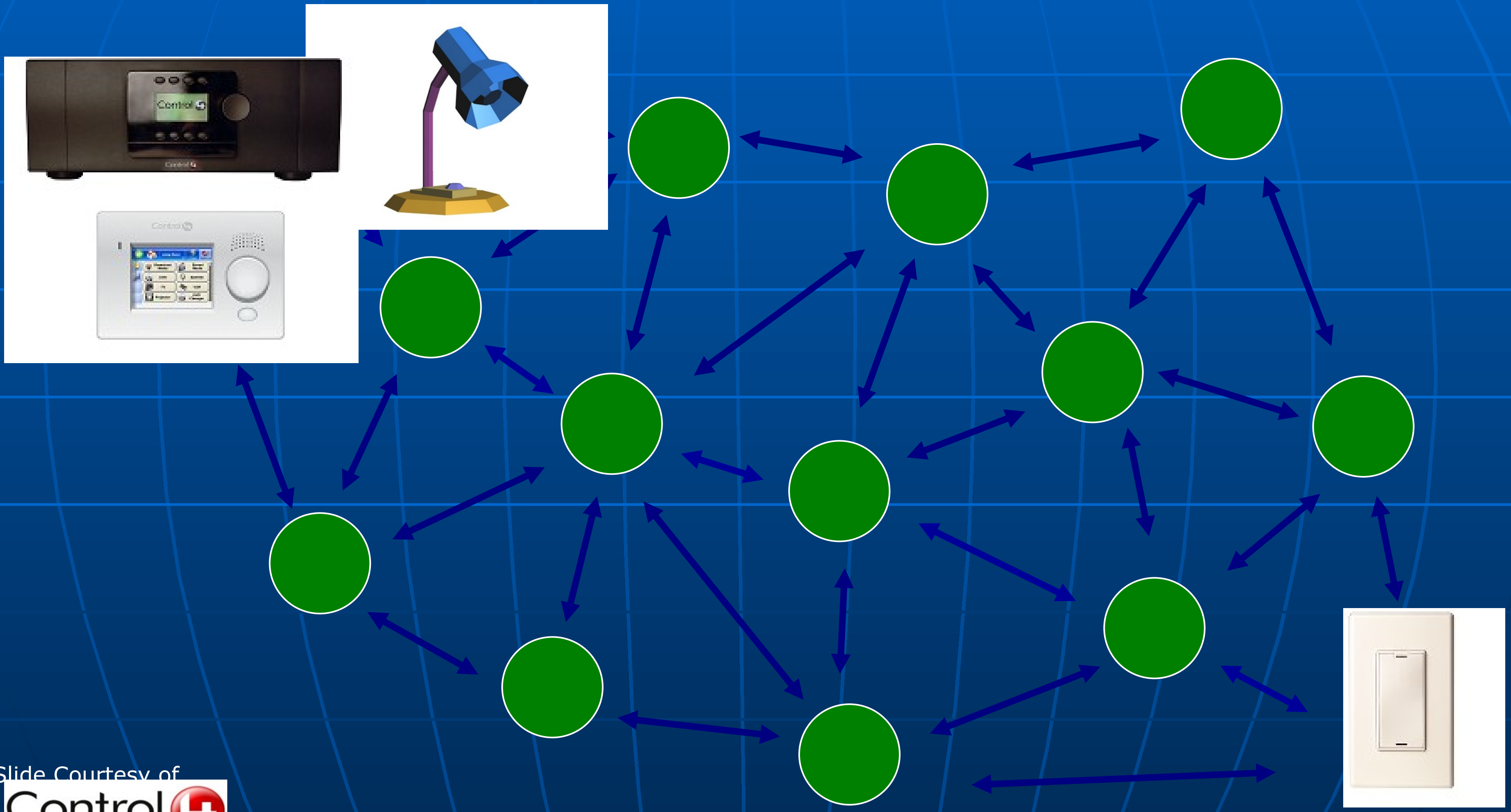
security
HVAC
lighting control
irrigation

ZigBee Mesh Networking



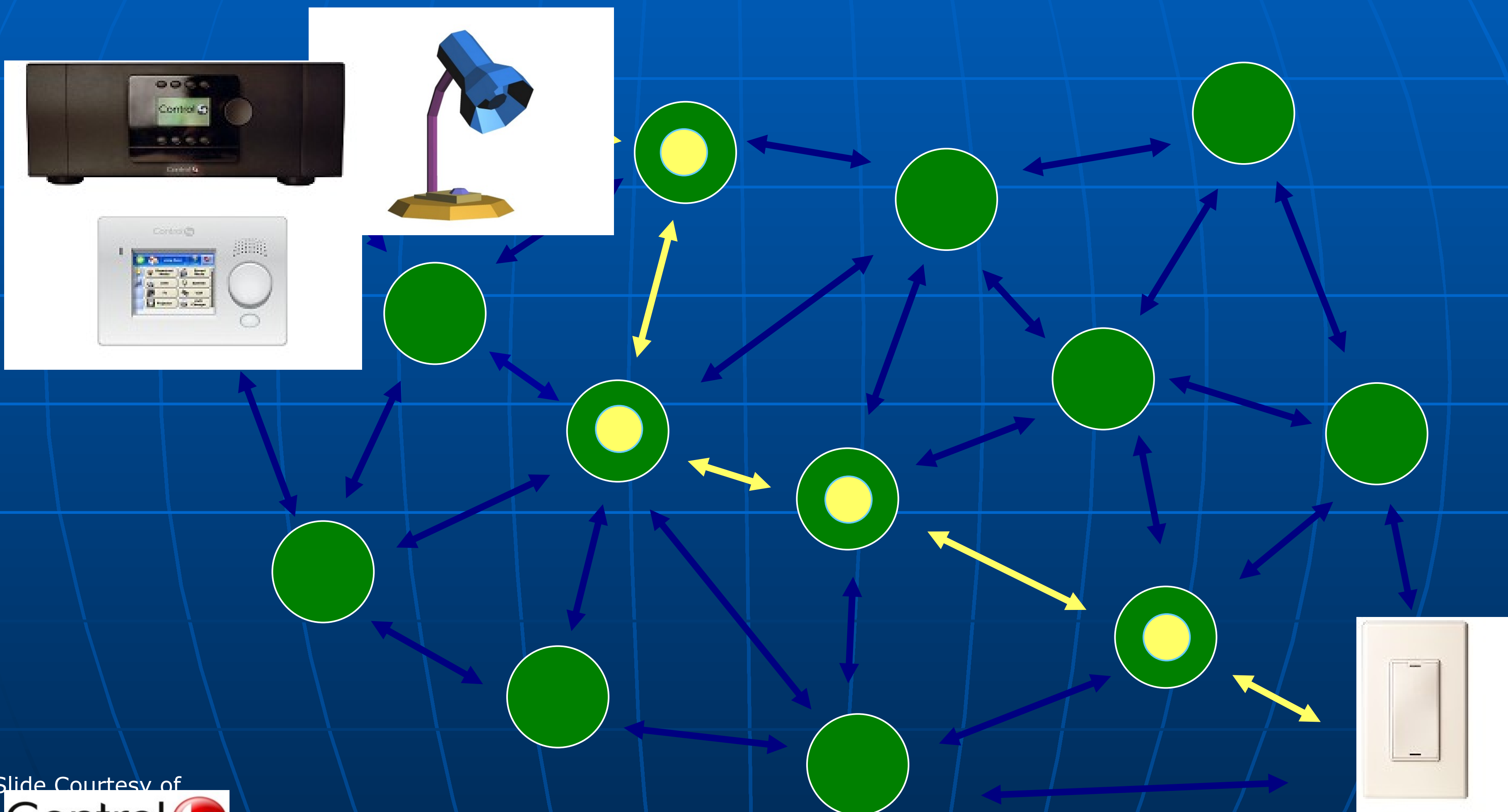
Slide Courtesy of Control4

ZigBee Mesh Networking



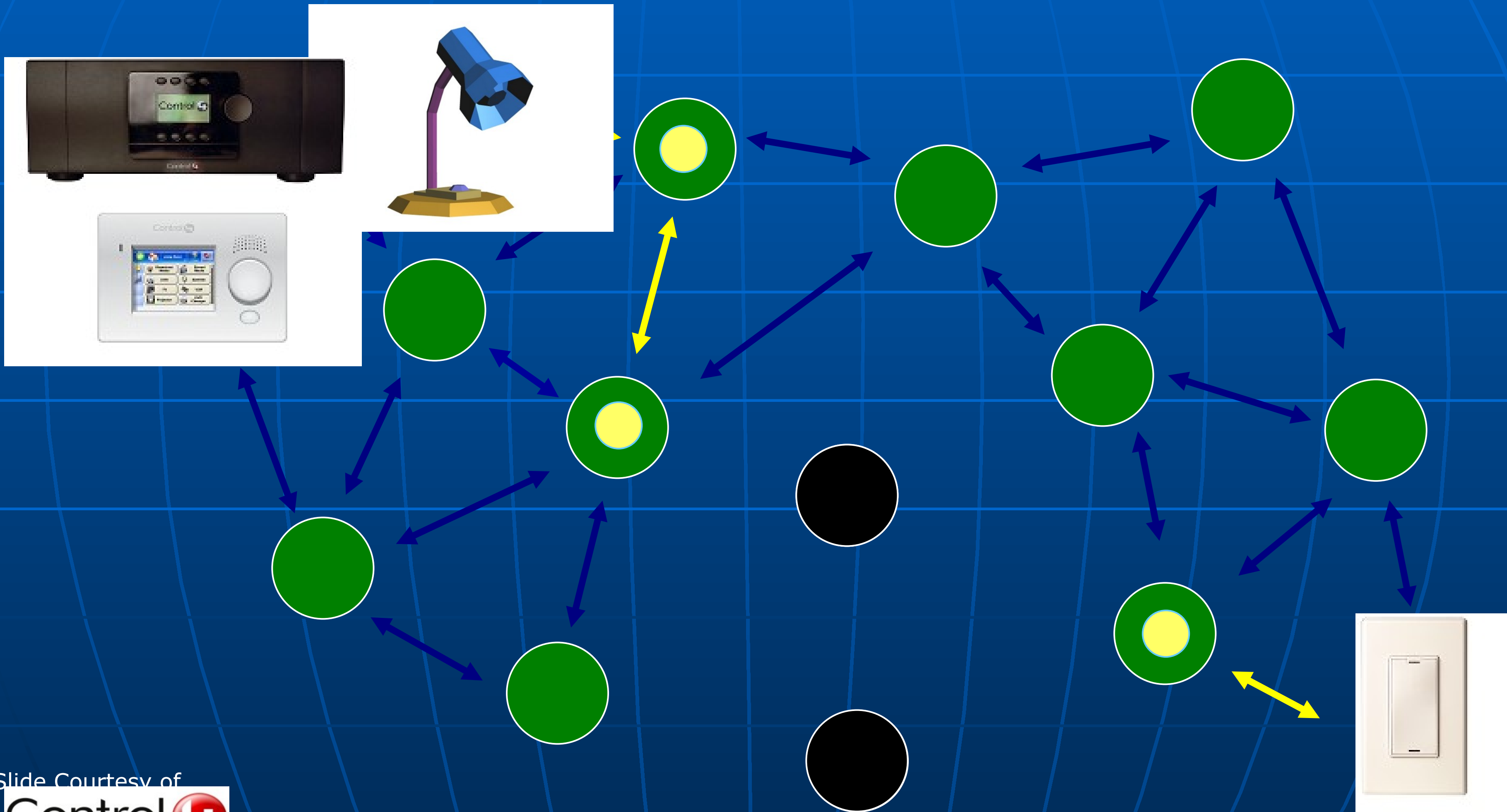
Slide Courtesy of Control4

ZigBee Mesh Networking



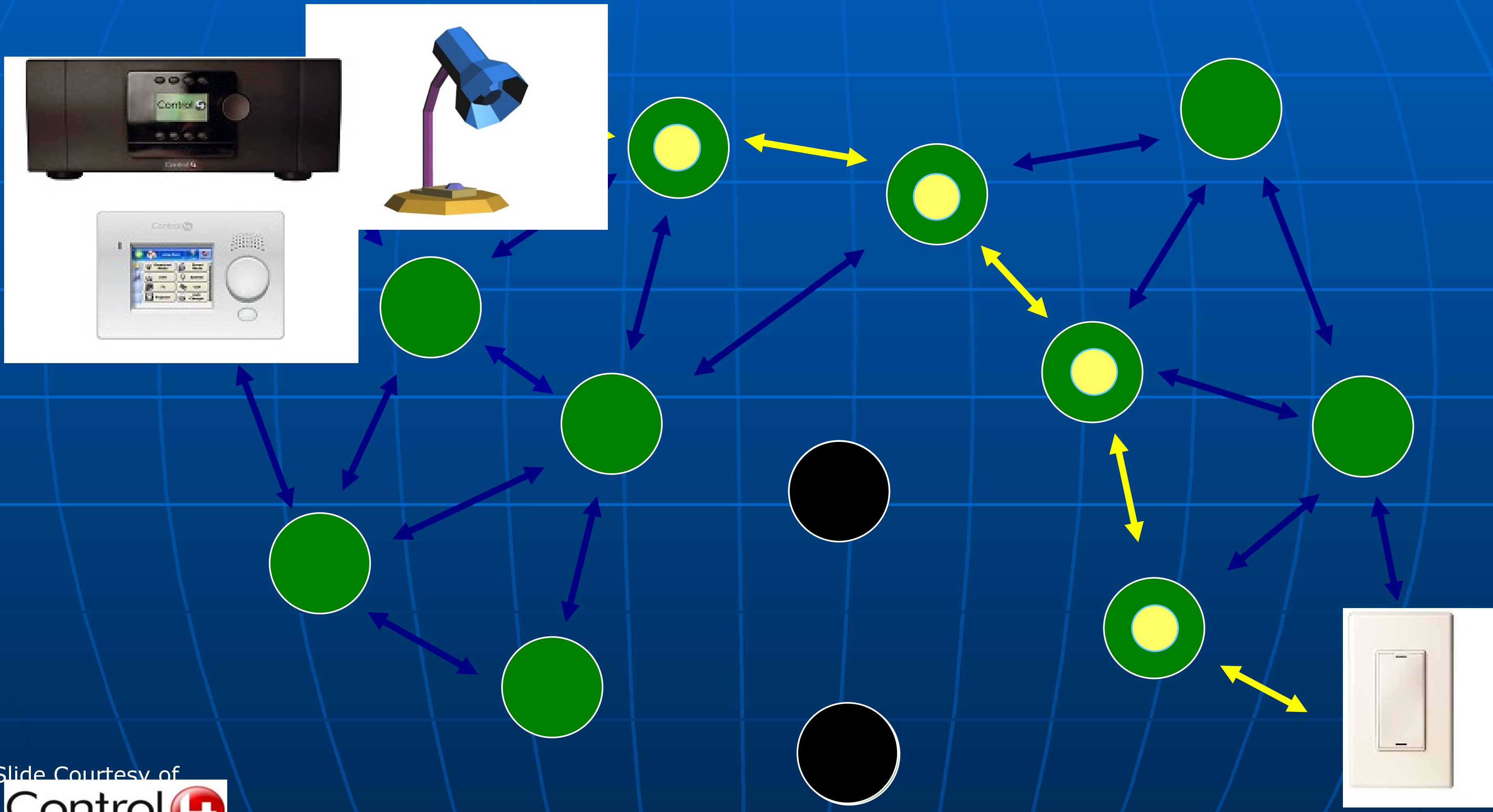
Slide Courtesy of

ZigBee Mesh Networking



Slide Courtesy of

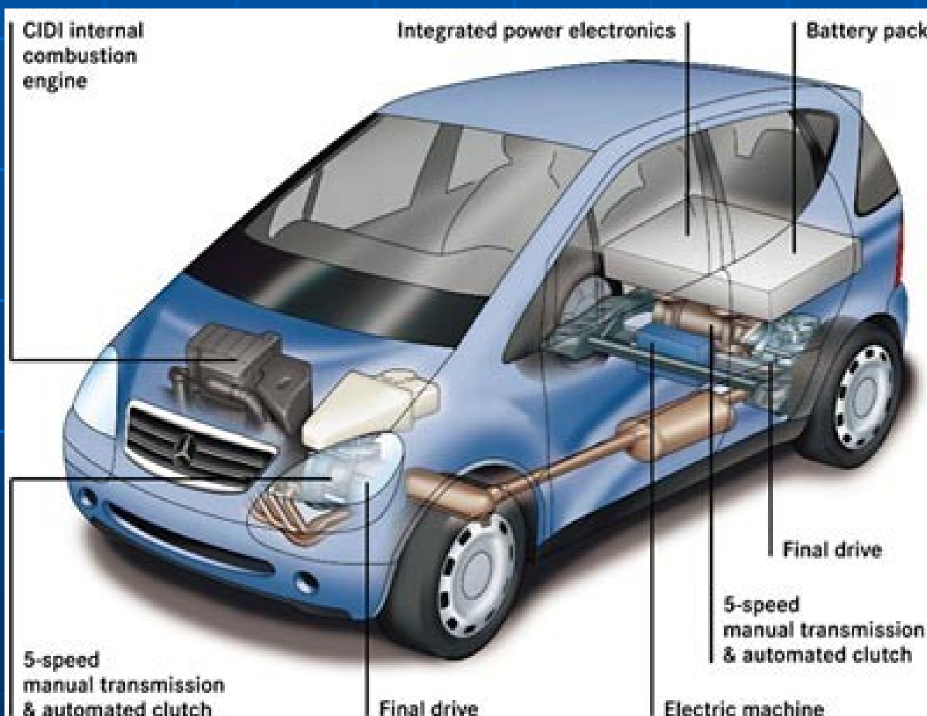
ZigBee Mesh Networking

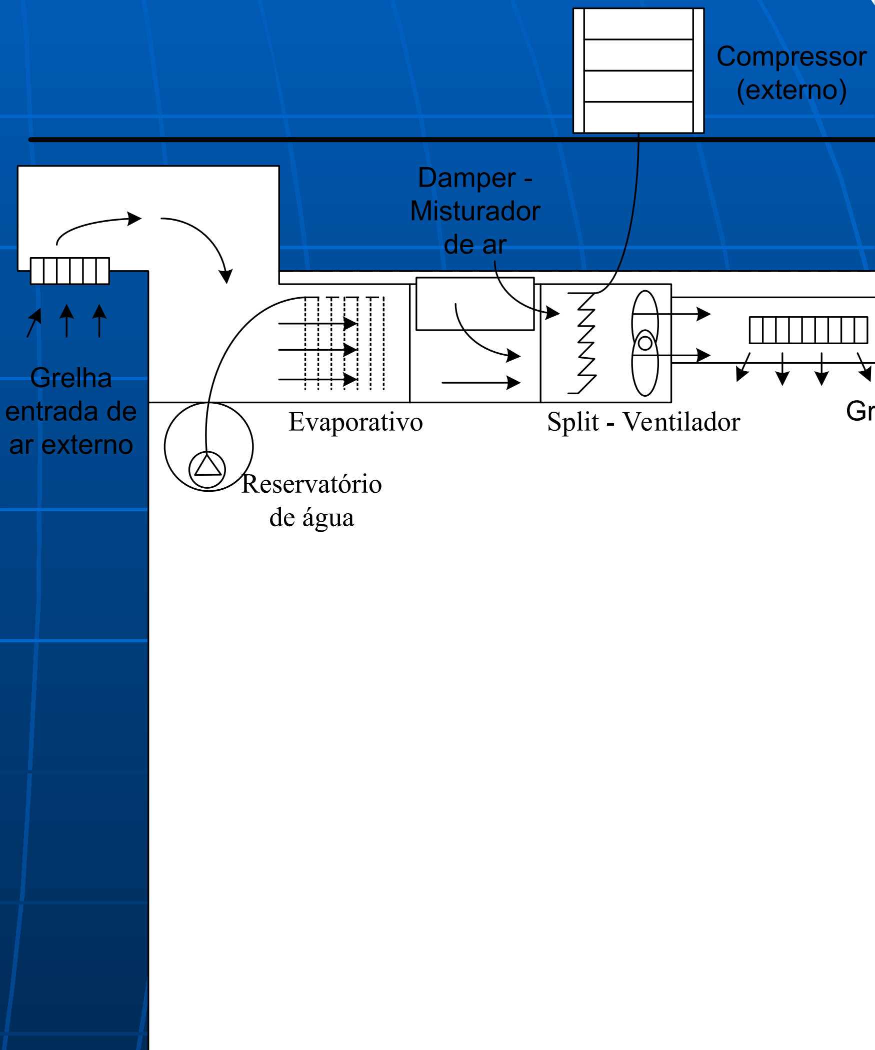


Slide Courtesy of

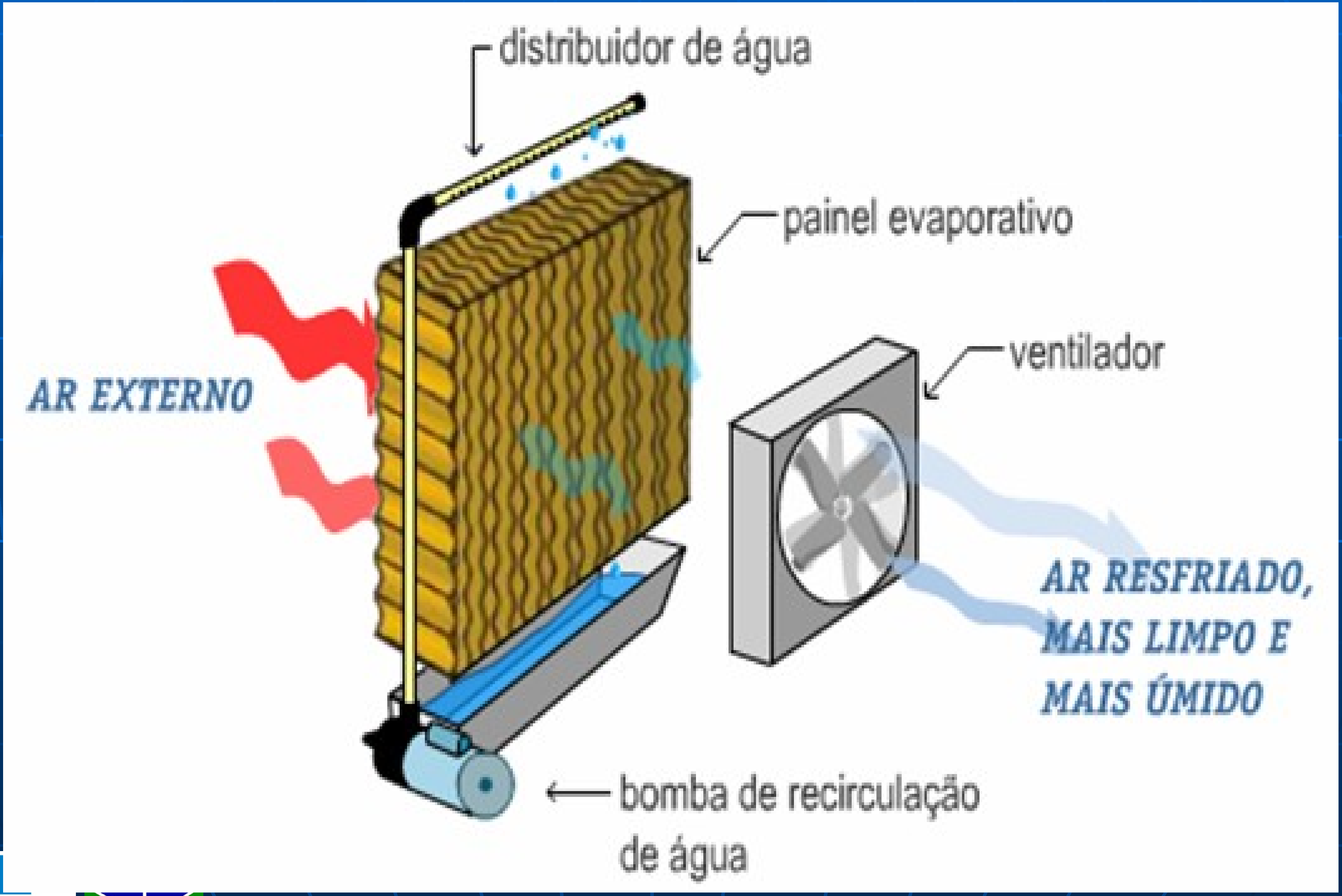
Energy Saving:

Hybrid Car / Hybrid Air Conditioner

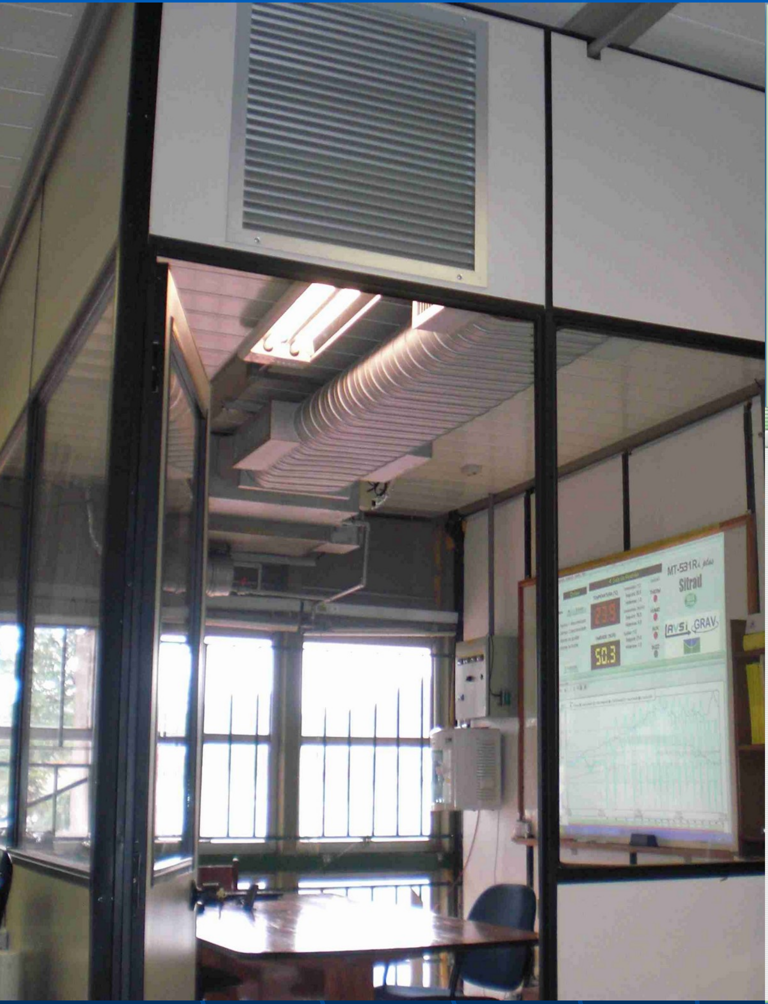


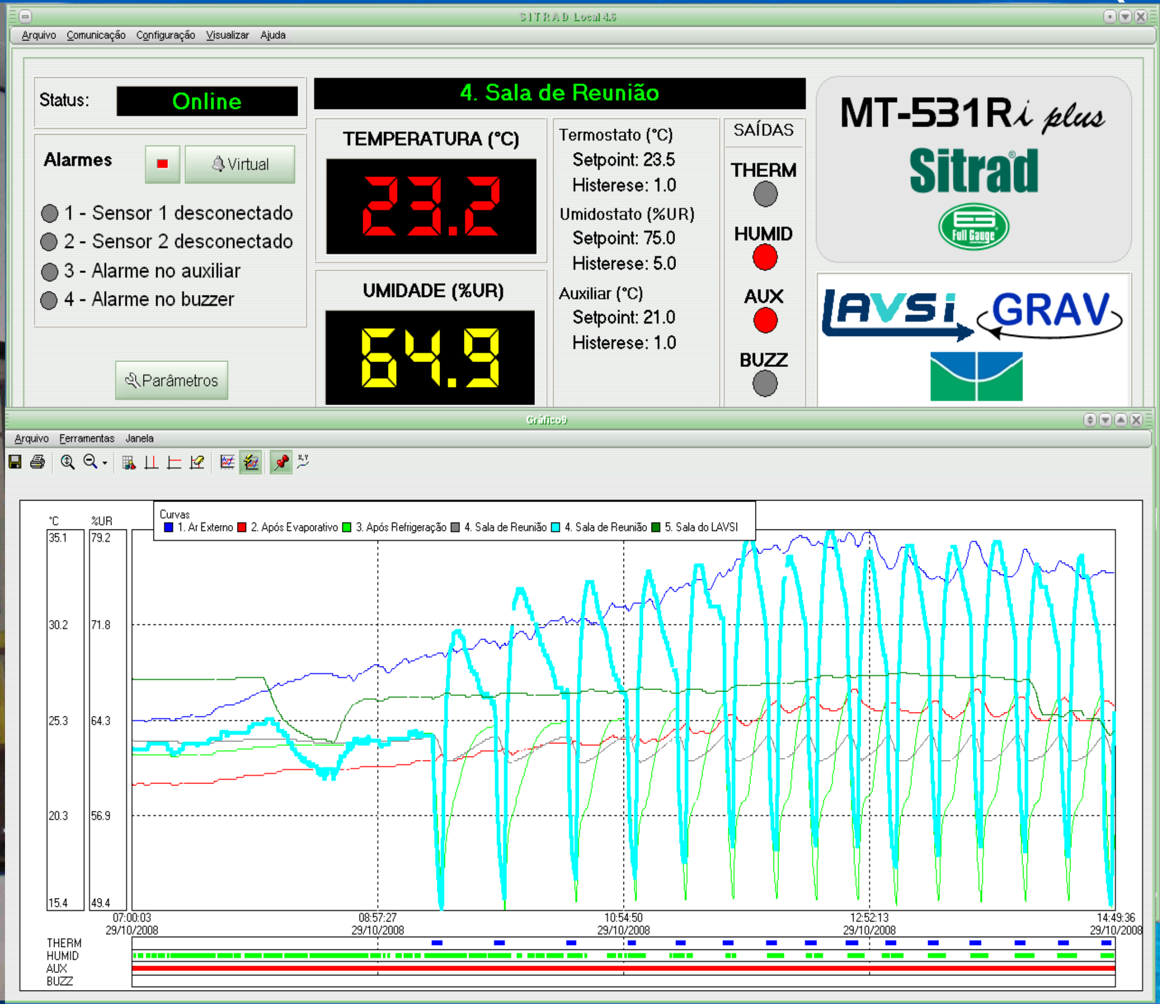


Fundamentos – Resfriamento evaporativo



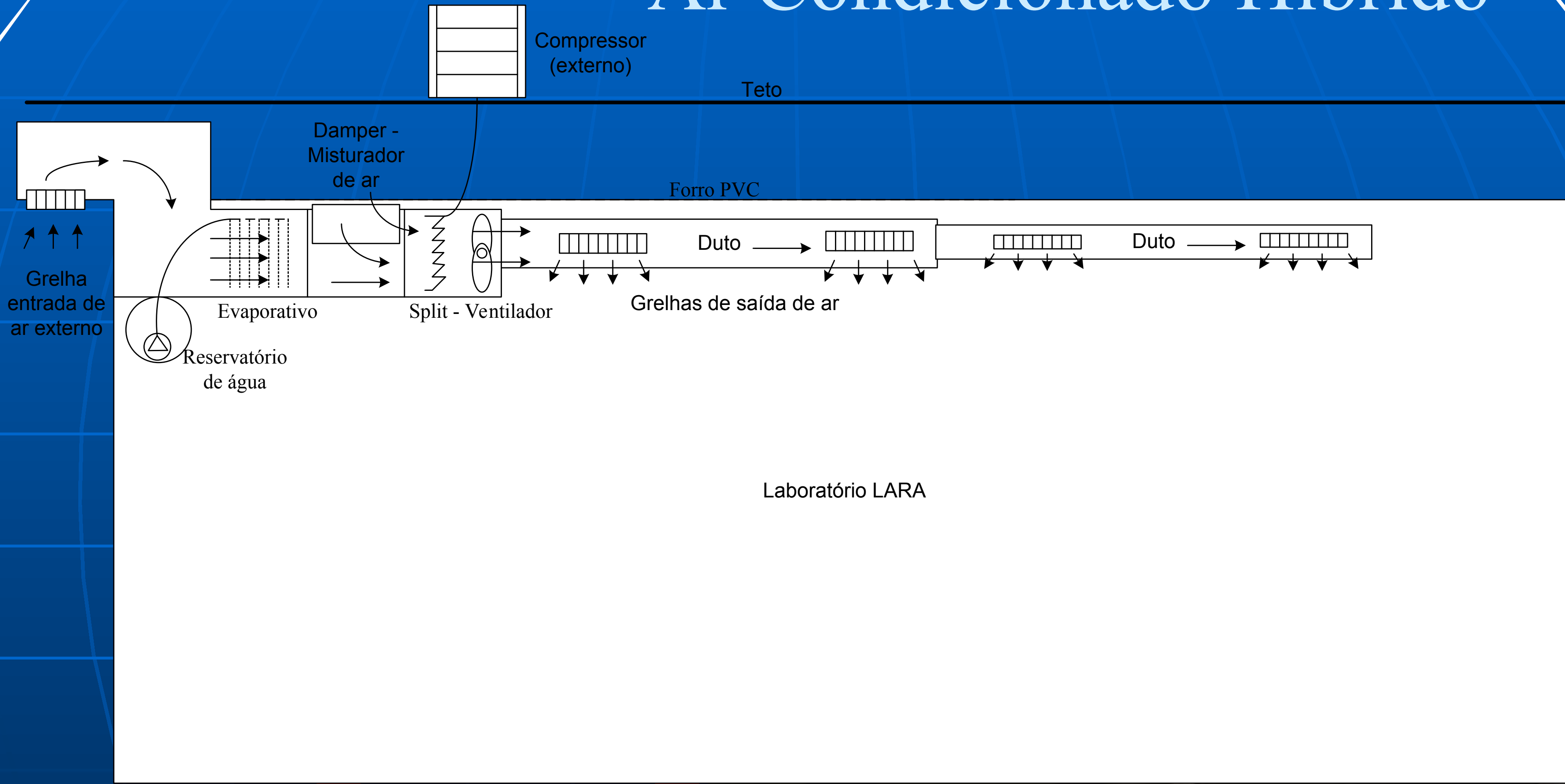
Hybrid Climatization: Evaporative-Conventional





M.Sc José Luis Olmos Flores, 2009

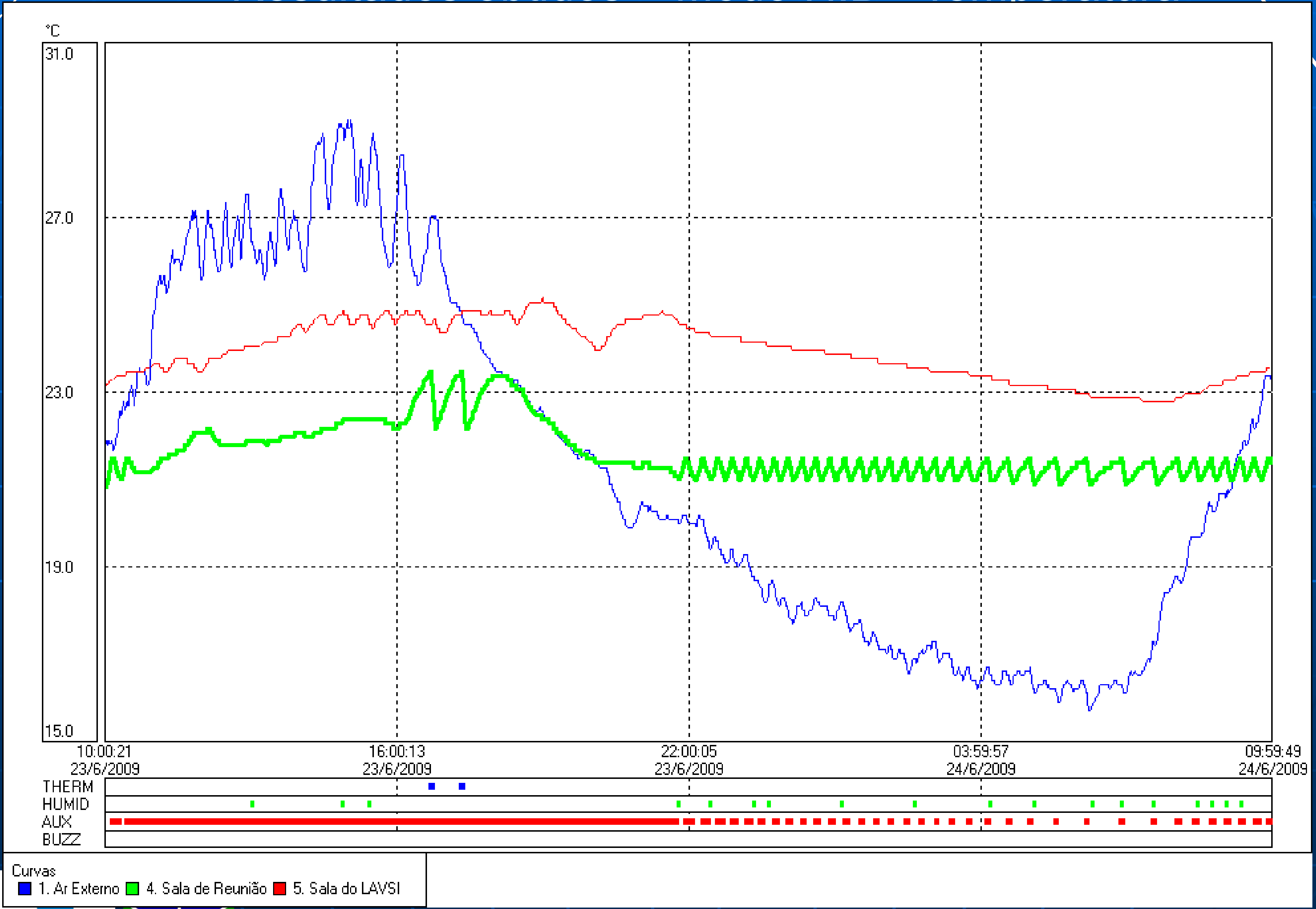
Ar Condicionado Híbrido



Redução de 70%!!

Análise de dados – Tela do *Software Sitrad*

Resultados obtidos – Modo HIB - Temperatura

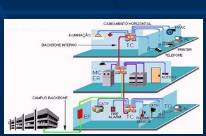


Análise de dados – Consumo de energia elétrica – 24 h.

Modo de Operação	Tempo operação Ventilador	Tempo operação Bomba	Tempo operação Compressor	Consumo total de Energia	Observações
DESL	00h00m00s	00h00m00s	00h00m00s	0,17 kWh	Muito Baixo
VENT	22h15m45s	00h00m00s	00h00m00s	2,23 kWh	Normal
EVAP	13h52m54s	00h29m42s	00h00m00s	1,36 kWh	Normal
REF	22h58m08s	00h00m00s	01h49m57s	5,92 kWh	Alto
HIB	14h56m31s	00h28m40s	00h09m02s	1,95 kWh	Normal

Intelligent Building Automation

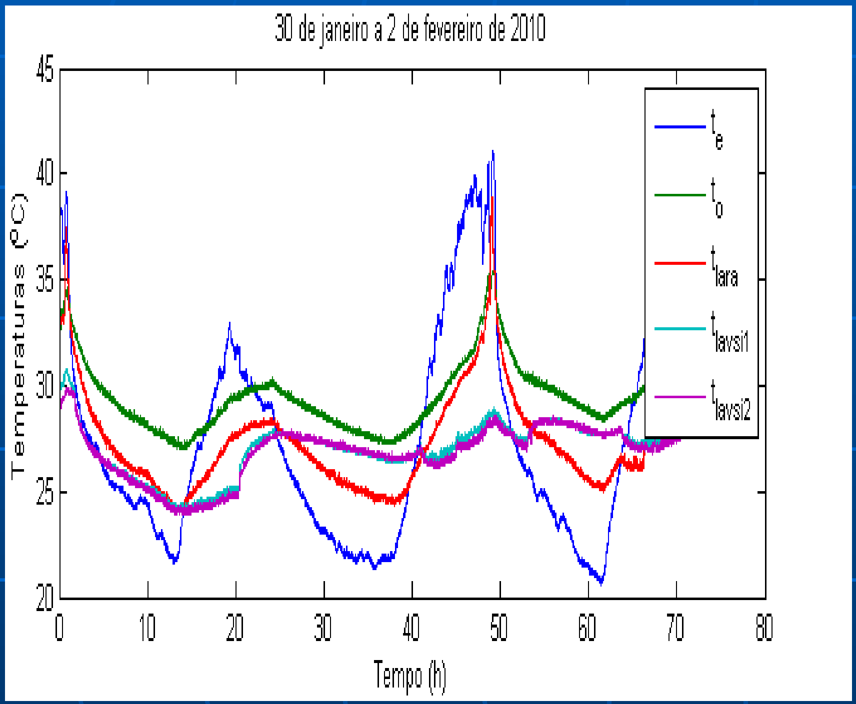
Laboratório de Automação e Robótica - ENE/UnB



mobile Thermal Comfort sensor module

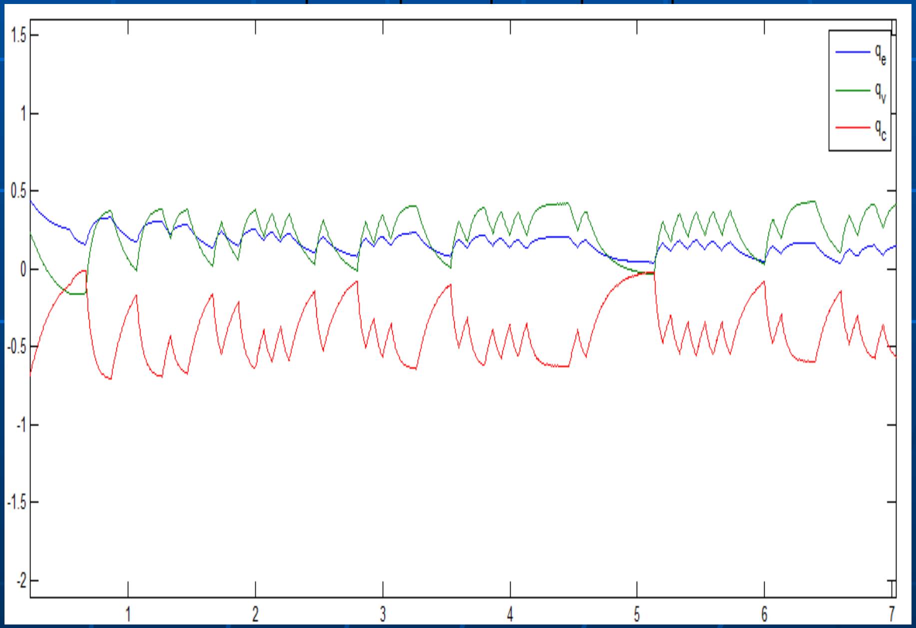
LARA/UnB - First-Principles Identification

M.Sc. Flávio Augusto R. de Oliveira, 2010



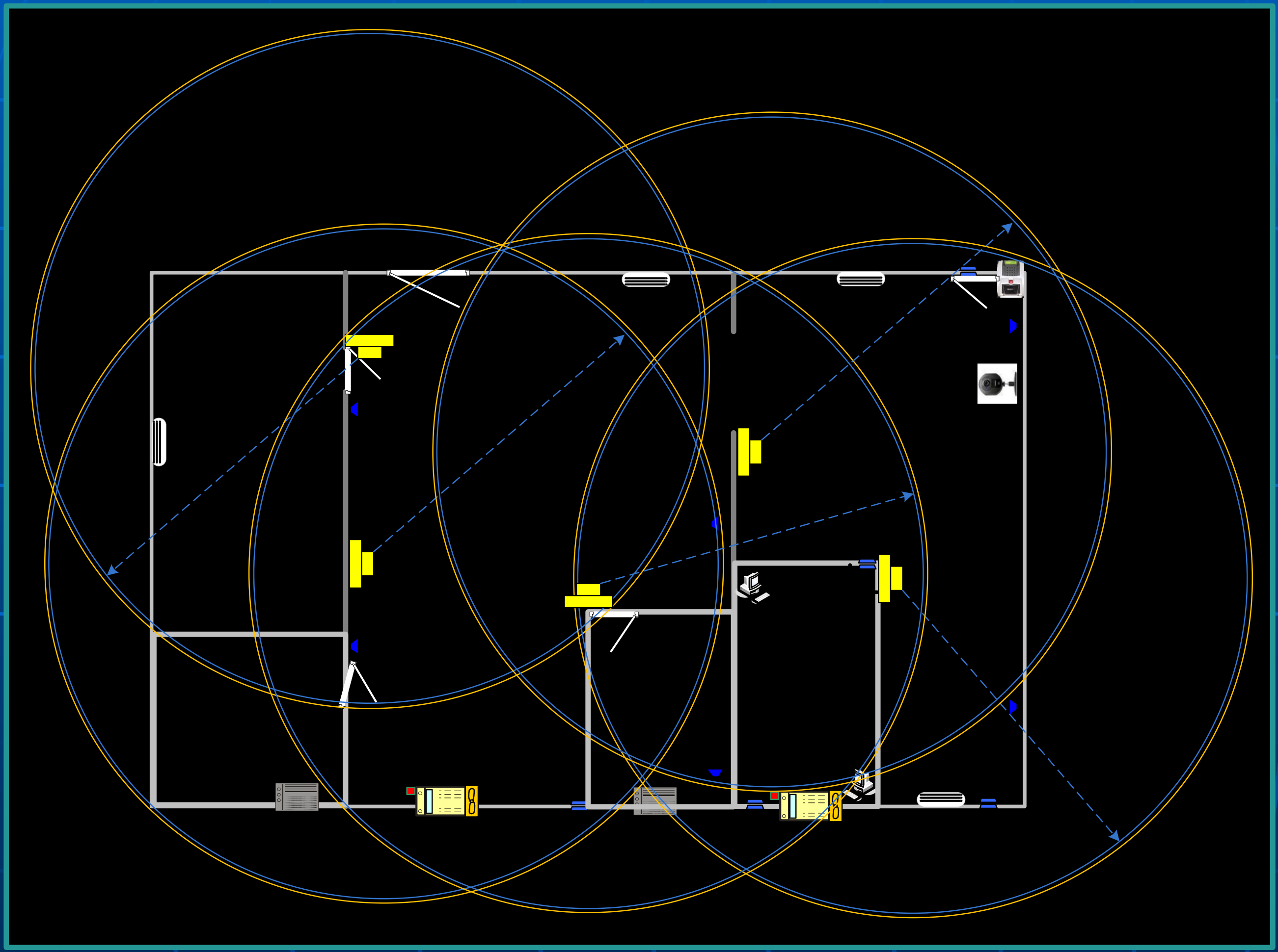
Measured identification data

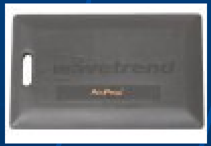
I	e	v	c
a_i	220	321.3	175.4



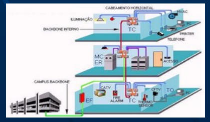
Estimated heat and colling flow

RFID occupancy identification for thermal load estimation





Eng. Josué Souza & Eng. Ariel Souza, 2011



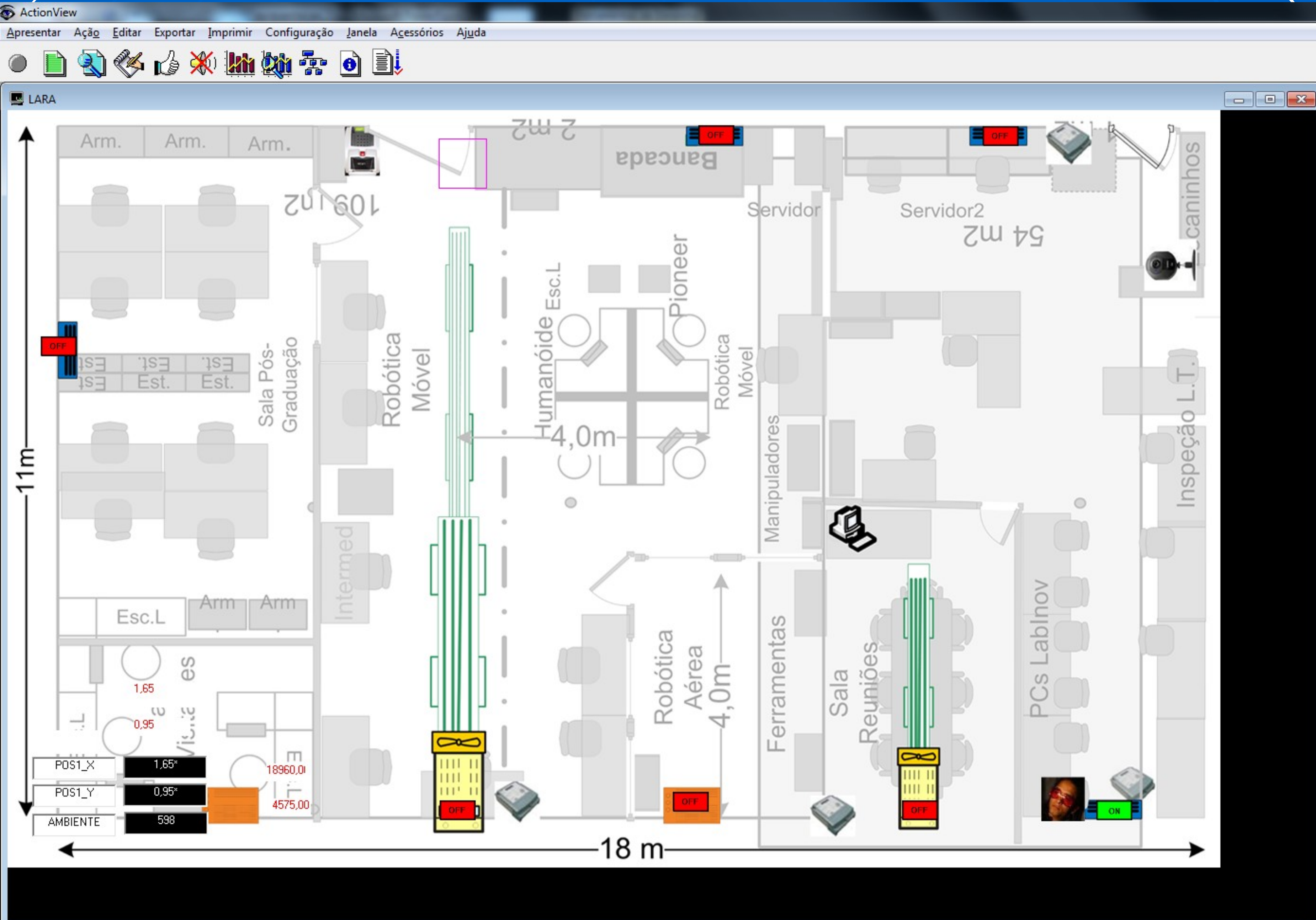
Active Tags

- Battery
- Microcontroller
- Motion Detector

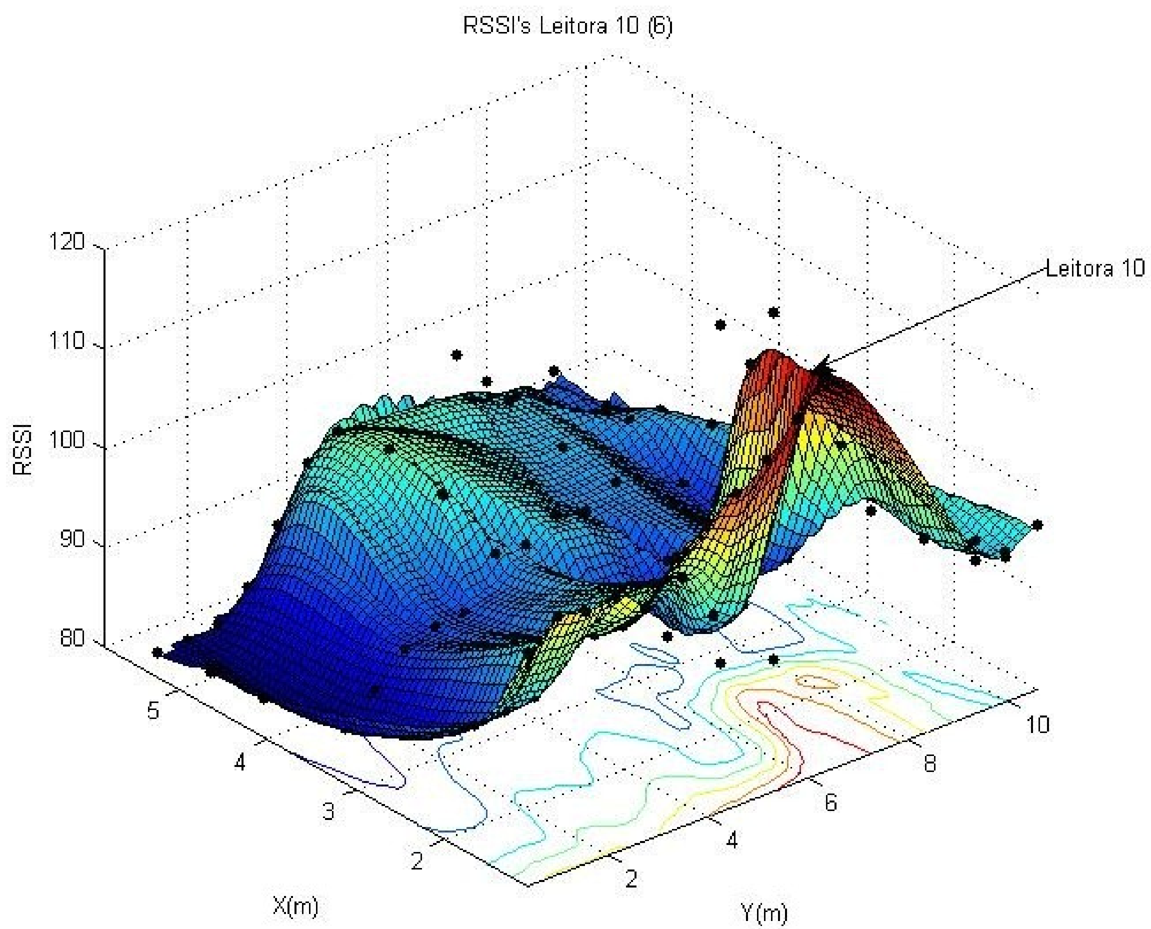
Send 39 bytes; used in this work:

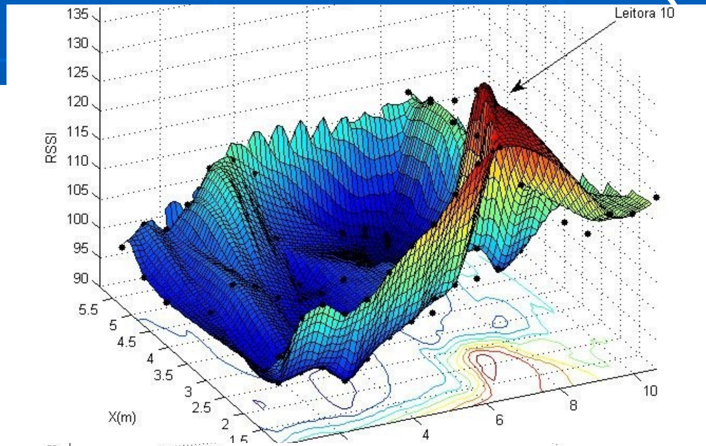
TagID	• Unique tag Identity
Age	• Tag age, since assembled
RSSI	• Received Signal Strength Indicator
Interval	• Interval: 1.5 s (motion)/ 30 s (rest)

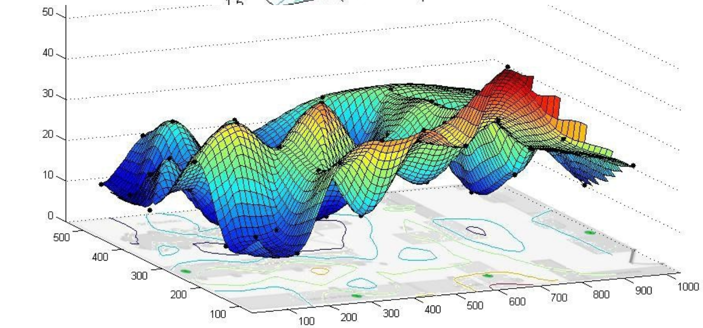
Actionview Runtime Screen

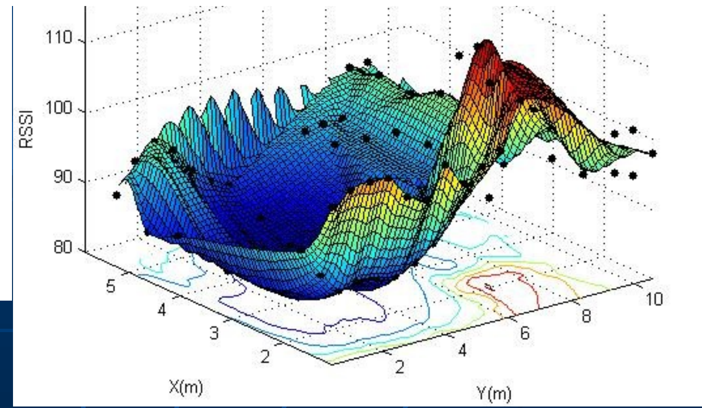


RSSI Mapping –
Data collected by Aramis Mobile Robot









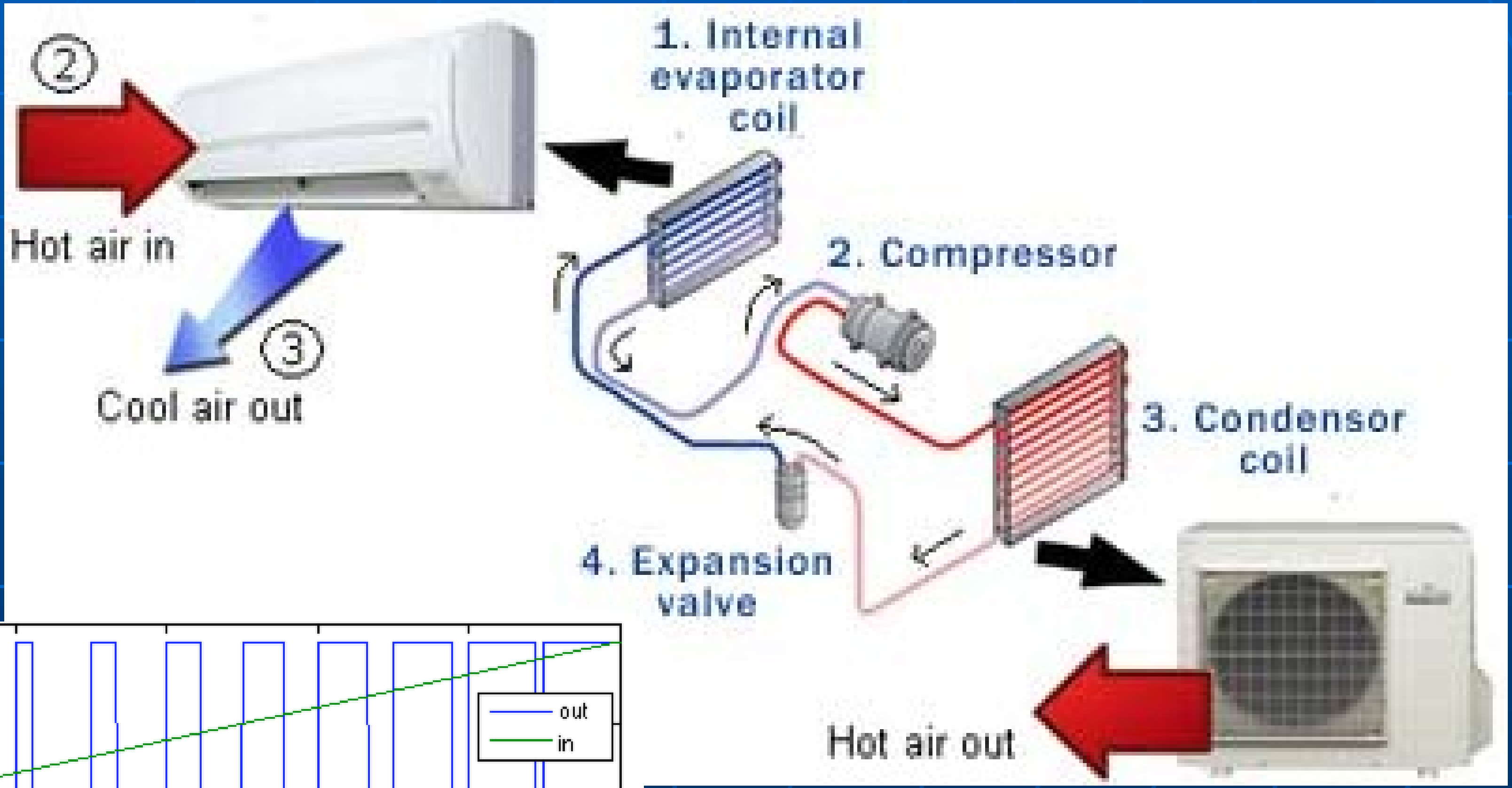
Energy Saving of Adaptive Thermal Control for PWM Driven Air-Conditioners

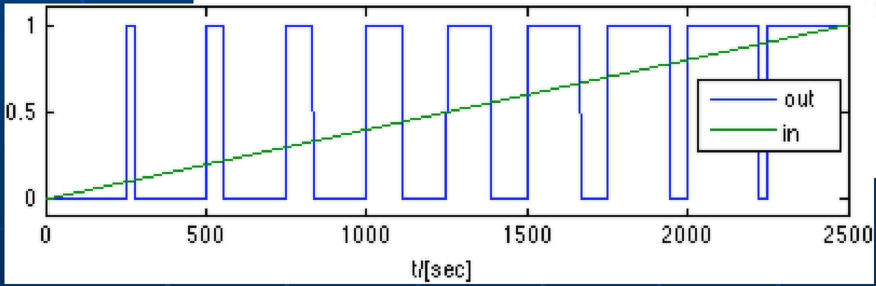
Enga. Marcella Cortat Campos Melo
Eng. Heyder Antonio Silva de Araújo
2014

- Variable Dynamics
  - Occupancy
  - External Temperature/Humidity
  - Activity
  - Season/Clothing

- Adaptive approach
  - Process Instrumentation
  - Recursive Identification

PWM for split air conditioner



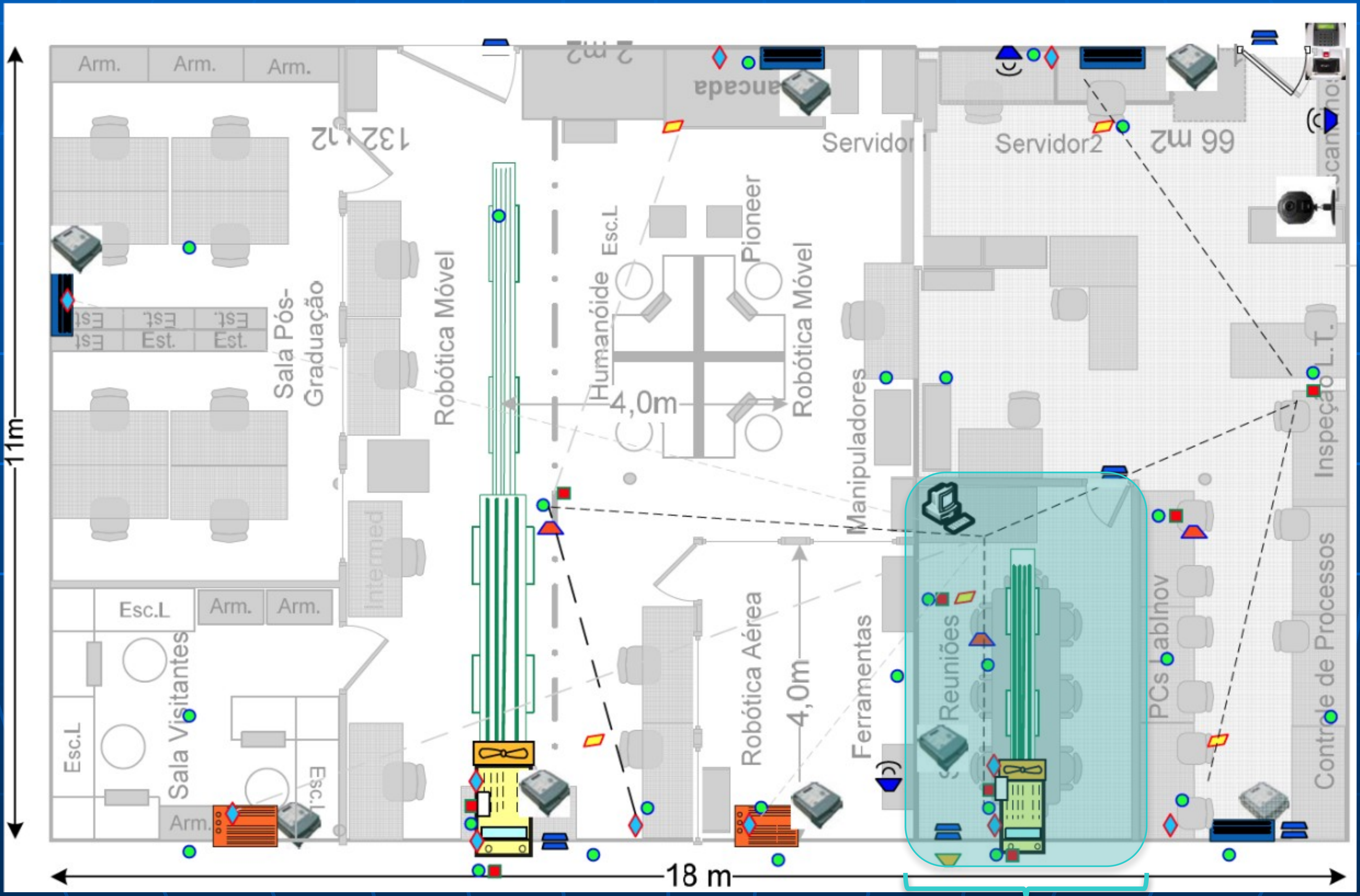


(adapted from airintelligence.co)

PWM *duty cycle* = 220 *s*

Adapitve Control
TEST ENVIRONMENT

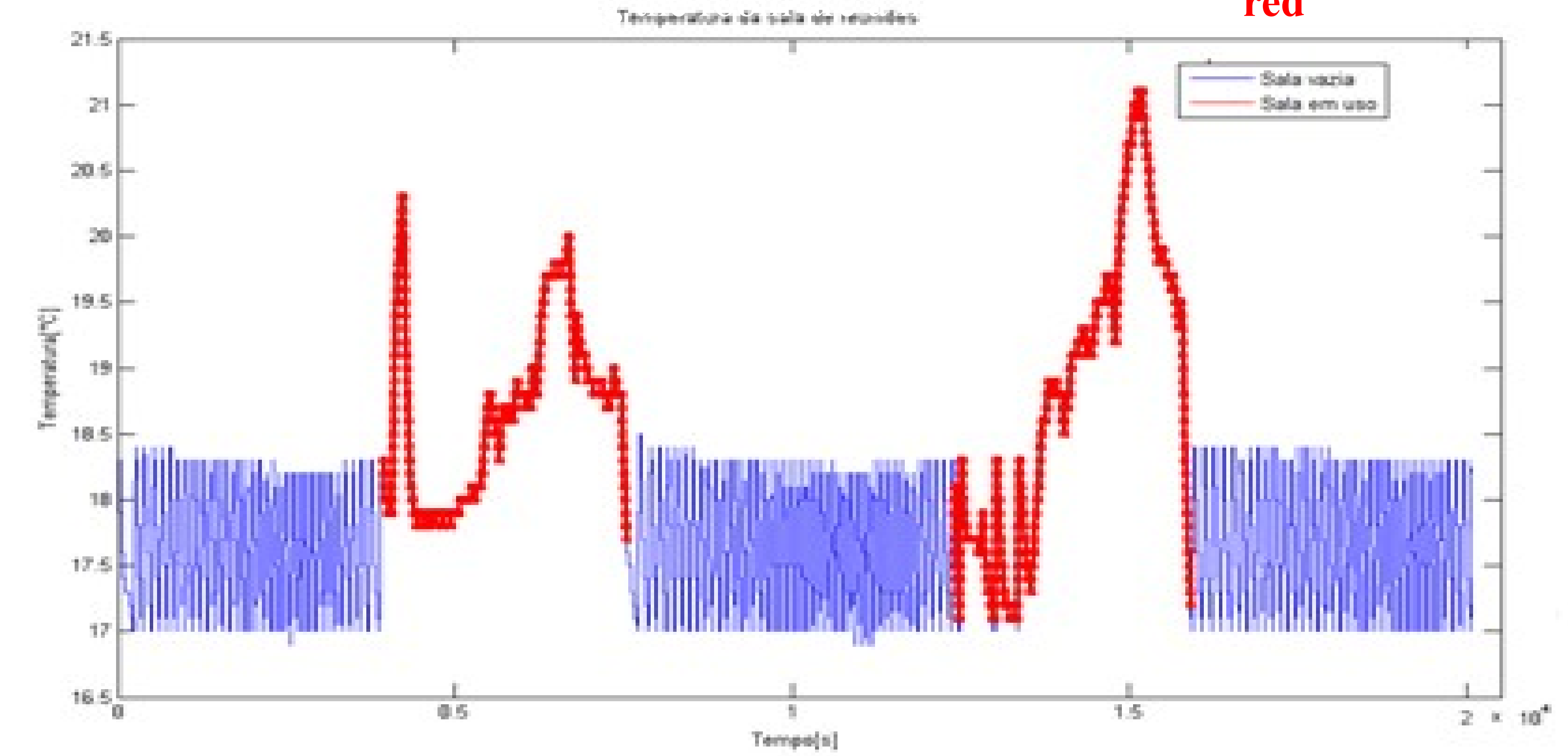
LARA/UnB
Brasília-BRAZIL



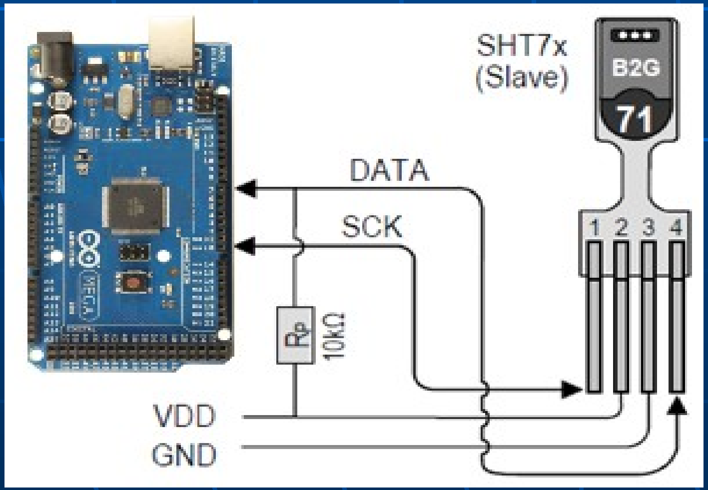
Meeting Room

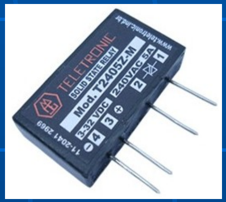
Temperature of the meeting room
- On-Off controller -

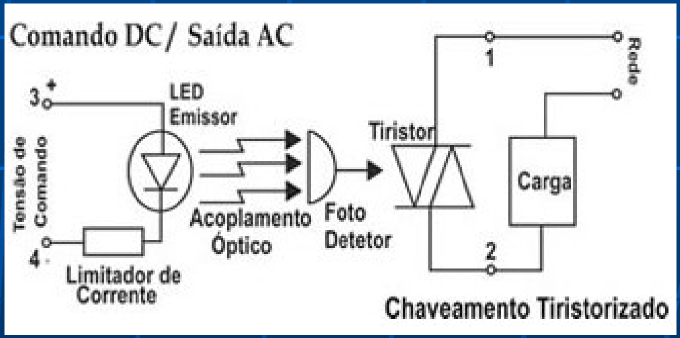
People entering/leaving the room are a major disturbance (**red**)



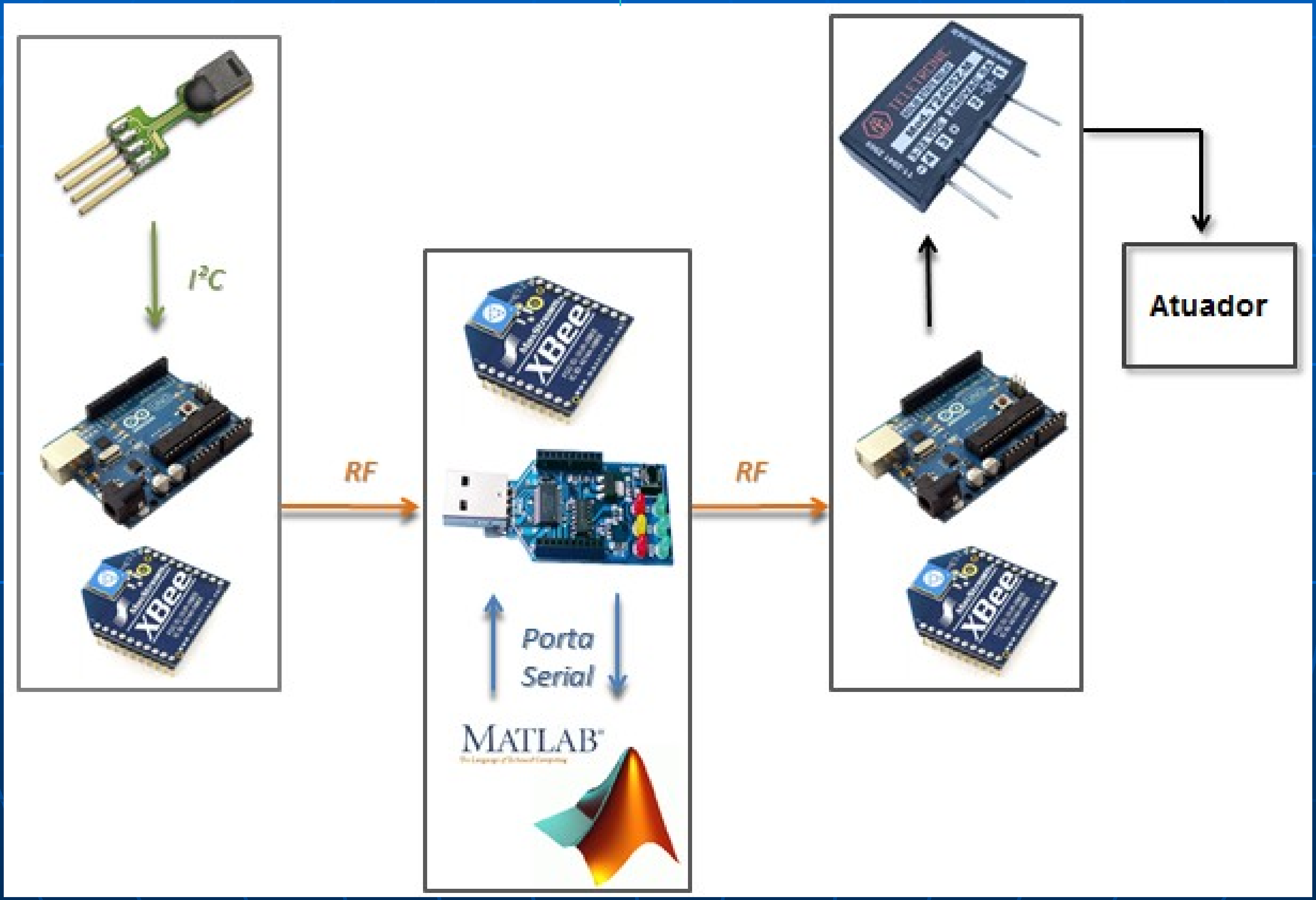
- Sensirion® SHT71
  - I²C Communication
  - Power Suply: 2,4 V a 5,5 V
  - 8 to 14 bits A/D
- Arduino ATmega1280
- IEEE 802.15.4 (ZigBee) - Xbee Shield
- Solid State Rele T2405Z-M







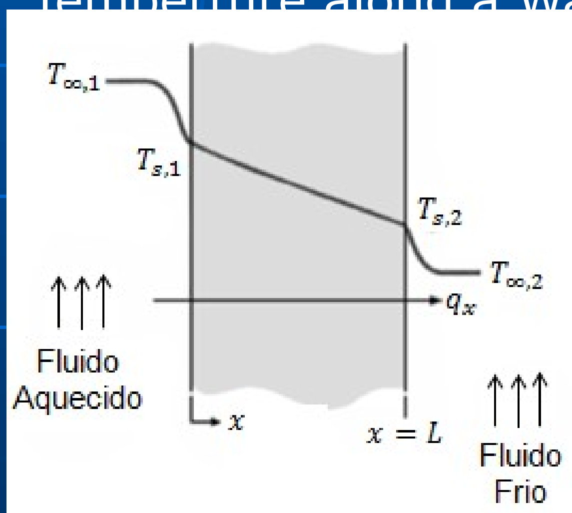
ZigBee Automation NETWORK

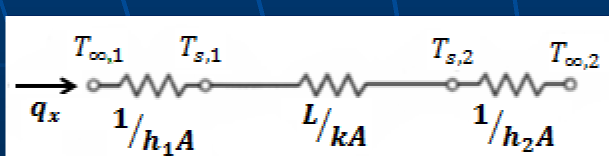


Recursive Identification needs a

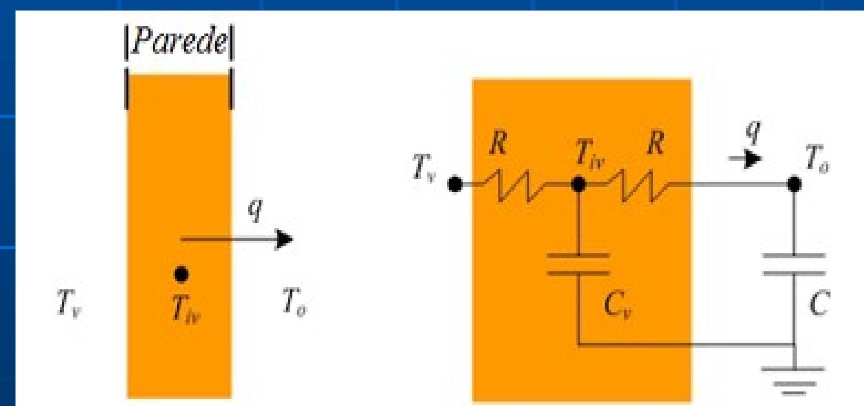
Structure for the Model -> Gray Box

Temperture along a Wall:

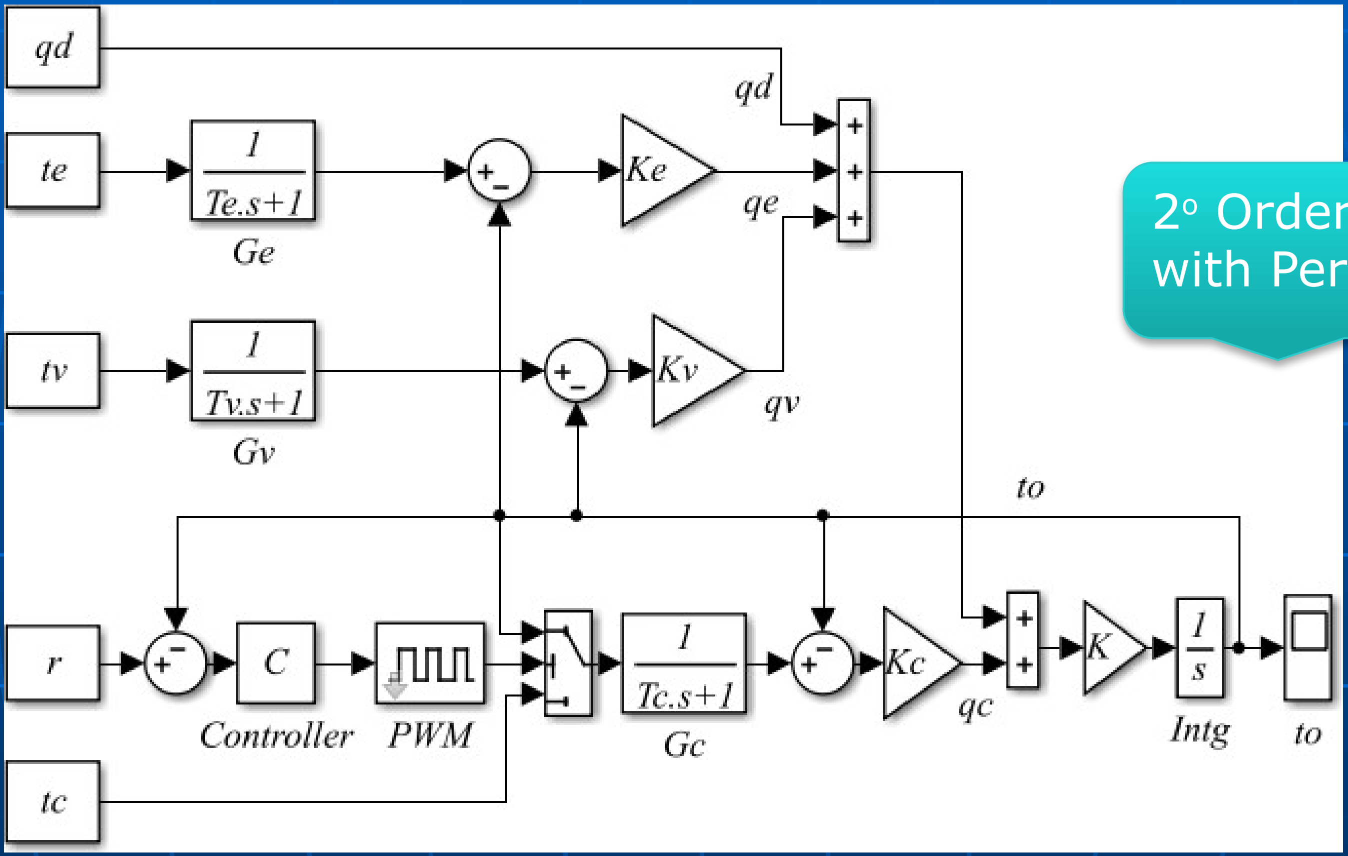




Thermal flow simplifications:



Wall analog Model



2º Order Dynamics with Perturbations

Temperatures: *r* - reference, *y* - controlled, *te* - external, *tv* -vicinity, *tc* - cooler
Time constants: *Te* , *Tv* , *Tc* . Gains: *Ke* , *Kv* , *Kc* , *K*
Heat flows: *qe* , *qc* , *qv* , *qd*

- Recursive Identification
  - Min. parameter variance
  - No bias
  - Plasticity

$$y(k) = \psi_k^T(k-1)\boldsymbol{\theta}_{\boldsymbol{k}} + \quad \xi(k)$$

Residue

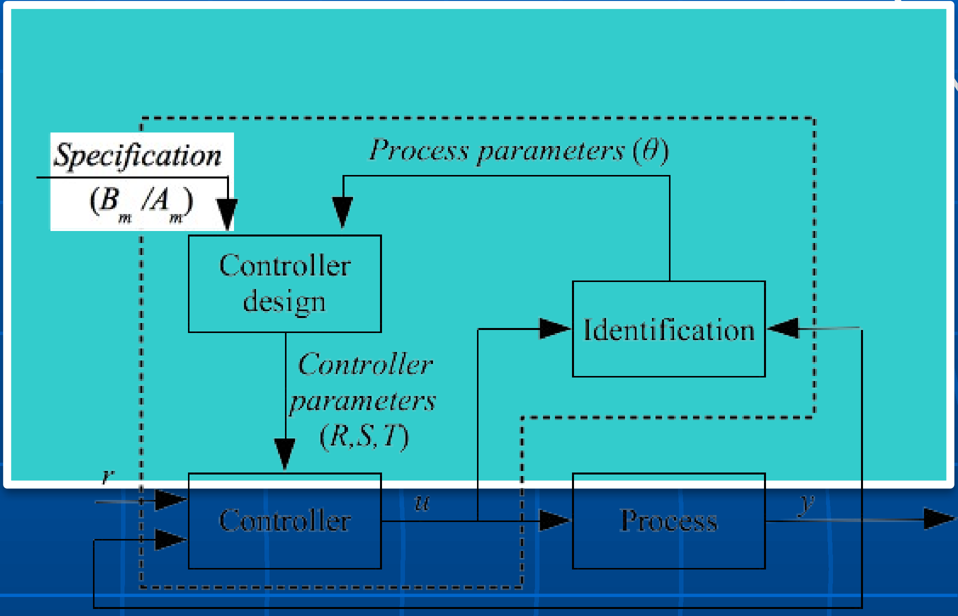
Parameter vector

Regressors (measurements)

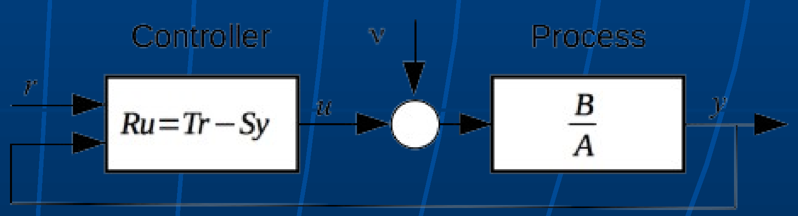
P = covariance matrix
λ = forgetting factor
y-$\psi\boldsymbol{\theta}$ = innovation
K = update gain

$$\begin{cases} K_k = \dfrac{P_{k-1}\psi_k}{\psi_k^T P_{k-1}\psi_k + \lambda}; \\ \boldsymbol{\theta}_{\boldsymbol{k}} = \boldsymbol{\theta}_{\boldsymbol{k-1}} + K_k[y(k) - \psi_k^T \boldsymbol{\theta}_{\boldsymbol{k-1}}]; \\ P_k = \dfrac{1}{\lambda}\left(P_{k-1} - \dfrac{P_{k-1}\psi_k\psi_k^T P_{k-1}}{\psi_k^T P_{k-1}\psi_k + \lambda}\right). \end{cases}$$

- Adaptive Control
  - Direct or ***Indirect***



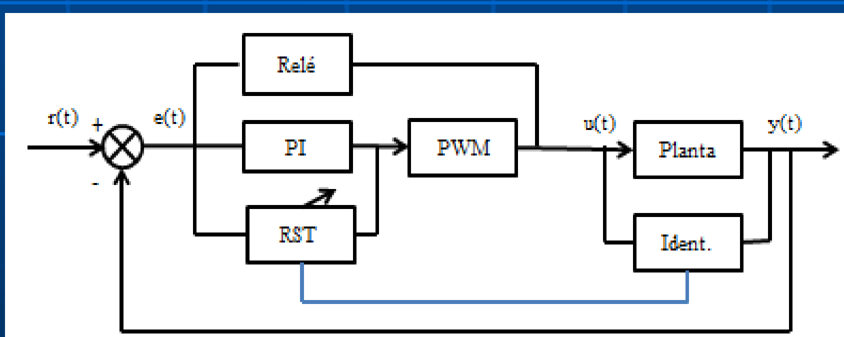
- Design Techniques:
  - Model Reference (MRAC)
  - ***Self-Tuning Regulator (RST)***
  - Dual Control
  - Gain Scheduling



Self-tuning RST controller - pole placement design

- On-Off Control

$$\begin{cases} 1 \;\; if \;\;\; y_{ref} - y < 1{,}0 \\ 0 \;\; if \;\;\; y_{ref} - y > 0{,}0 \end{cases}$$



- PID Control

Empiric Tuning by Chien, Hrone e Reswick, 1952.
where T_p is the time constant and τ is the deadtime.

Tipo de Contro-lador	Servo - 20% overshoot		
	K_p	T_i	T_d
P	$0.7T_p/\tau$	-	-
PI	$0.6T_p/\tau$	τ	-
PID	$0.95T_p/\tau$	1.4τ	0.47τ

$$D_{PI}(z) = \frac{-0.41424(z-0.9975)}{z-1}$$

– Adaptive Control (Aström and Wittenmark, 95)

Model with input noise $A(k)y(k) = B(u(k) + v(k))$

Pole assignment controller $Ru(k) = Tr(k) - Sy(k)$ R, S, T *– to be designed.*

$$y(k) = \frac{BT}{AR + BS} r(k) + \frac{BR}{AR + BS} v(k) \qquad A_c = \boxed{AR + BS}$$

Identified Model
$$G(z) = \frac{b_0 z + b_1}{z^2 + a_1 z + a_2} z^{-d}$$

Reference Model
$$A_m y_m(k) = B_m r(k)$$

Control Law

...

$$u(k) = f[u(k-1), y(k-2), y(k-1), y(k), r(k), b_2, b_1, a_2, a_1, a_0, b_{m2}, b_{m1}, a_{m2}, a_{m1}, a_{m0}]$$

MEETING ROOM

– Identification

- Model:

$$G(z)=\frac{b_0 z+b_1}{z^2+a_1 z+a_2}z^{-d}$$

- Regressor Vector:

$$\psi(k)=[\,y(k-1)\;y(k-2)\;u(k-5)\;u(k-4)]$$

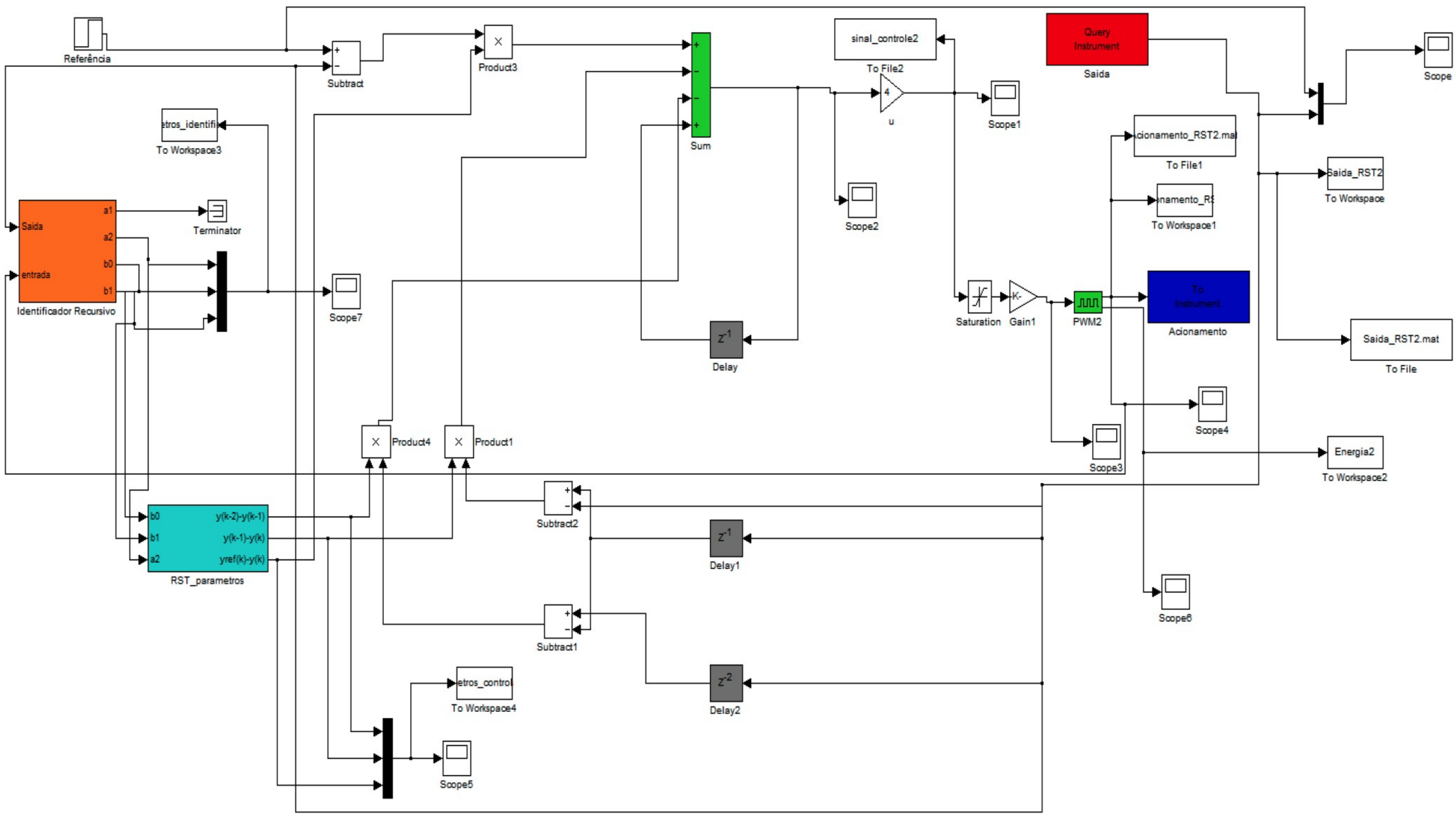
- Parameter Vector:

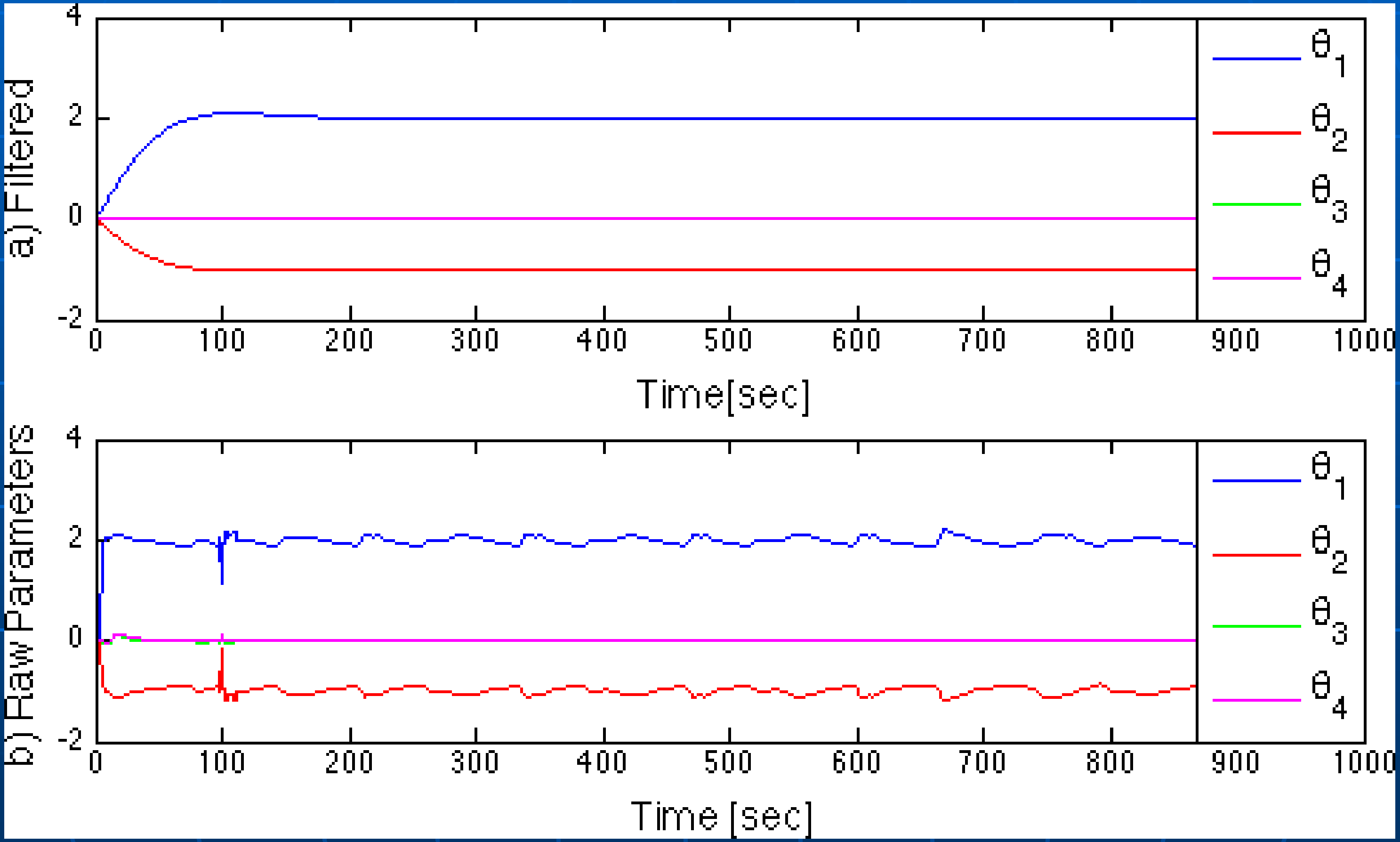
$$\theta(k)=[\theta_1\;\theta_2\;\theta_3\;\theta_4]^T$$

$$G(z)=\frac{-0.0219z+0.0154}{z^2-1.918z+0.919}z^{-3} \qquad G_m(z)=\frac{0.0925z}{z^2-1.0088z+0.08738}z^{-3}\ \ (\approx 5x\ faster\ than\ G(z))$$

(typical 91% fit)

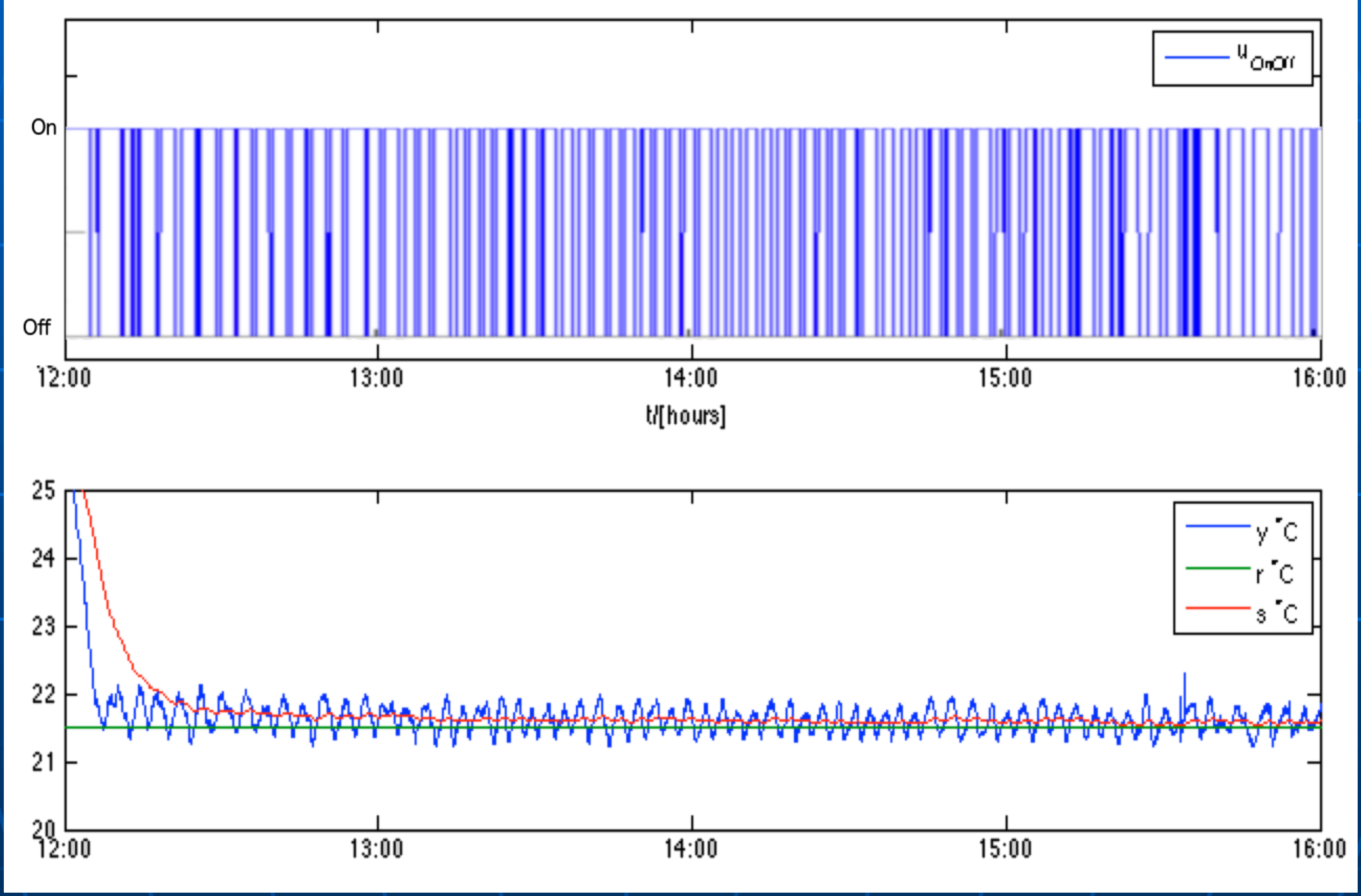
RST Adaptive Controller





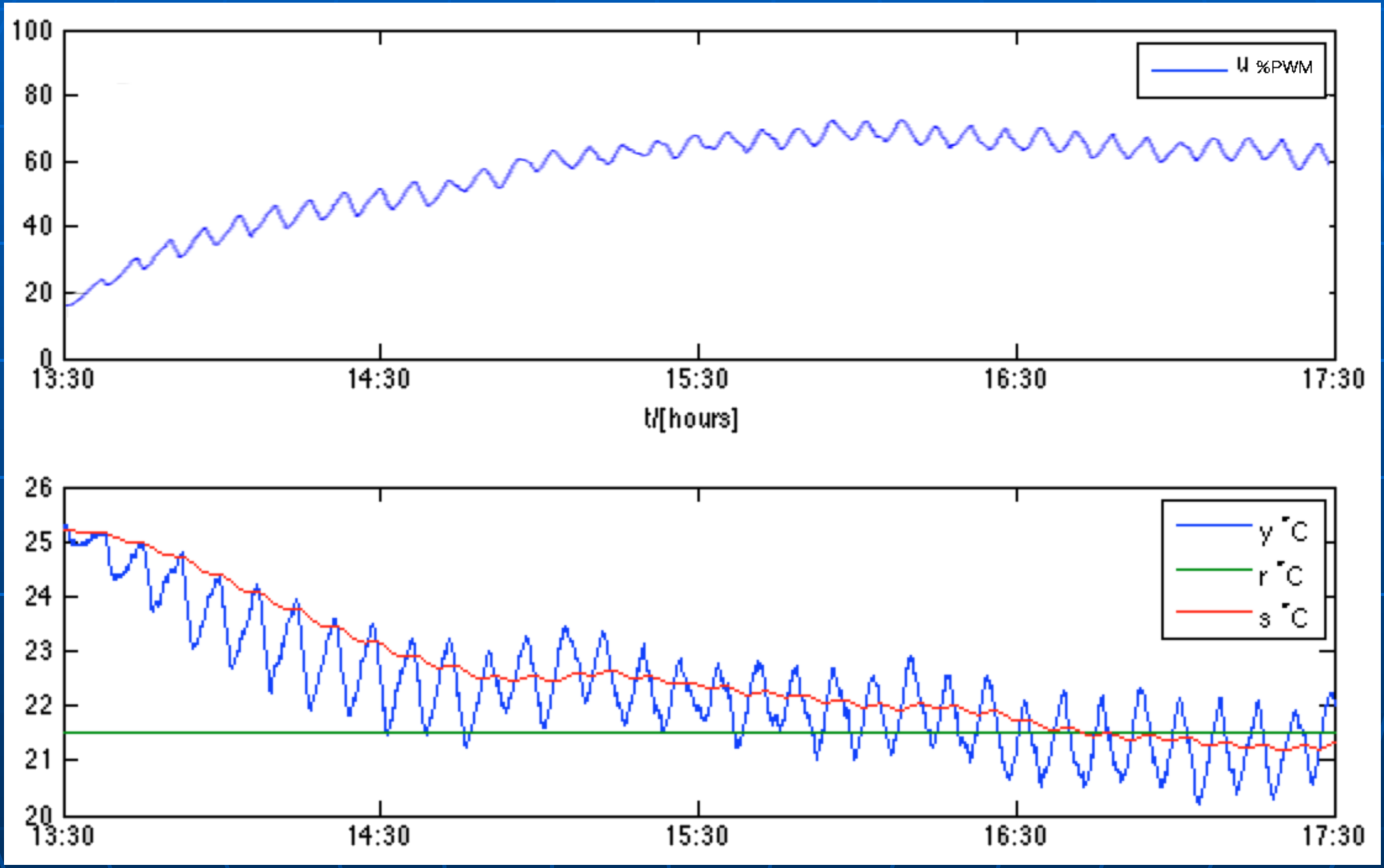
Estimated model parameters:
a) smooth filtered parameters, b) raw estimated model parameters.

ON-OFF



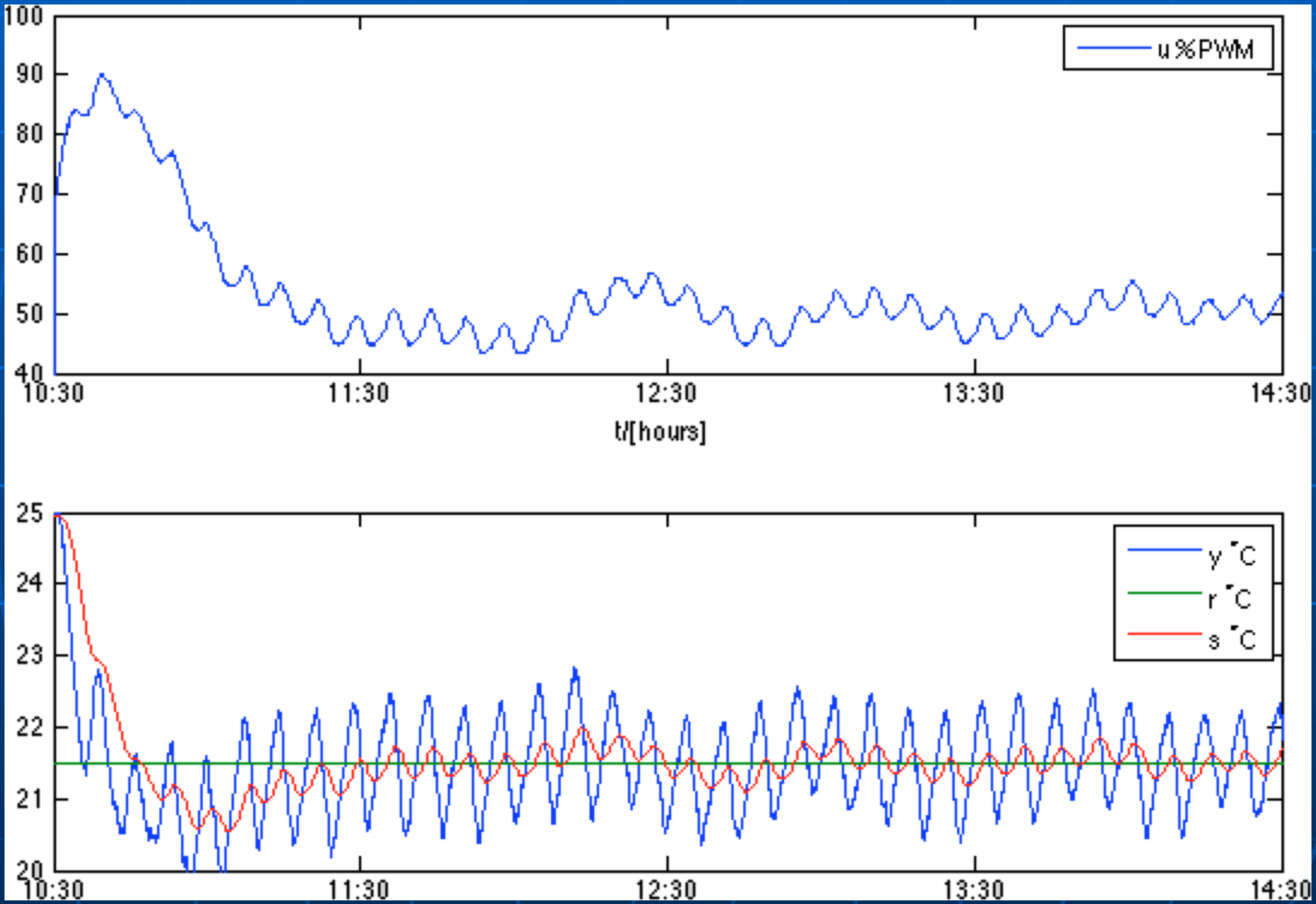
On-Off controller, variable thermal load.

PI



PI controller, variable thermal load.

RST



RST controller, variable thermal load.

ERROR - ENERGY

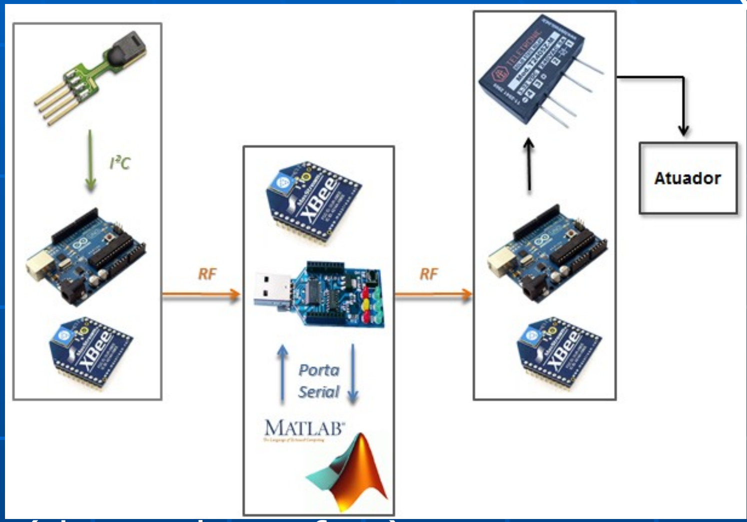
Table 1 - Controller Comparison – RMS error and Energy, 8-hour runs.

Thermal Load	ON-OFF Controller		PI Controller		Adaptive Controller	
	Error [RMS]	Energy [kWh]	Error [RMS]	Energy [kWh]	Error [RMS]	Energy [kWh]
Constant	0.14	6.69	1.55	3.12	0.53	3.42
Variable	0.12	7.89	1.18	4.84	0.43	4.63

Constant thermal load - empty meeting room's door kept closed.

Variable thermal Load - occupancy change:
meetings, studying, and vacancy periods.
Opening of the door -> large heat flow (process parameters change).

Better ADAPTIVE!

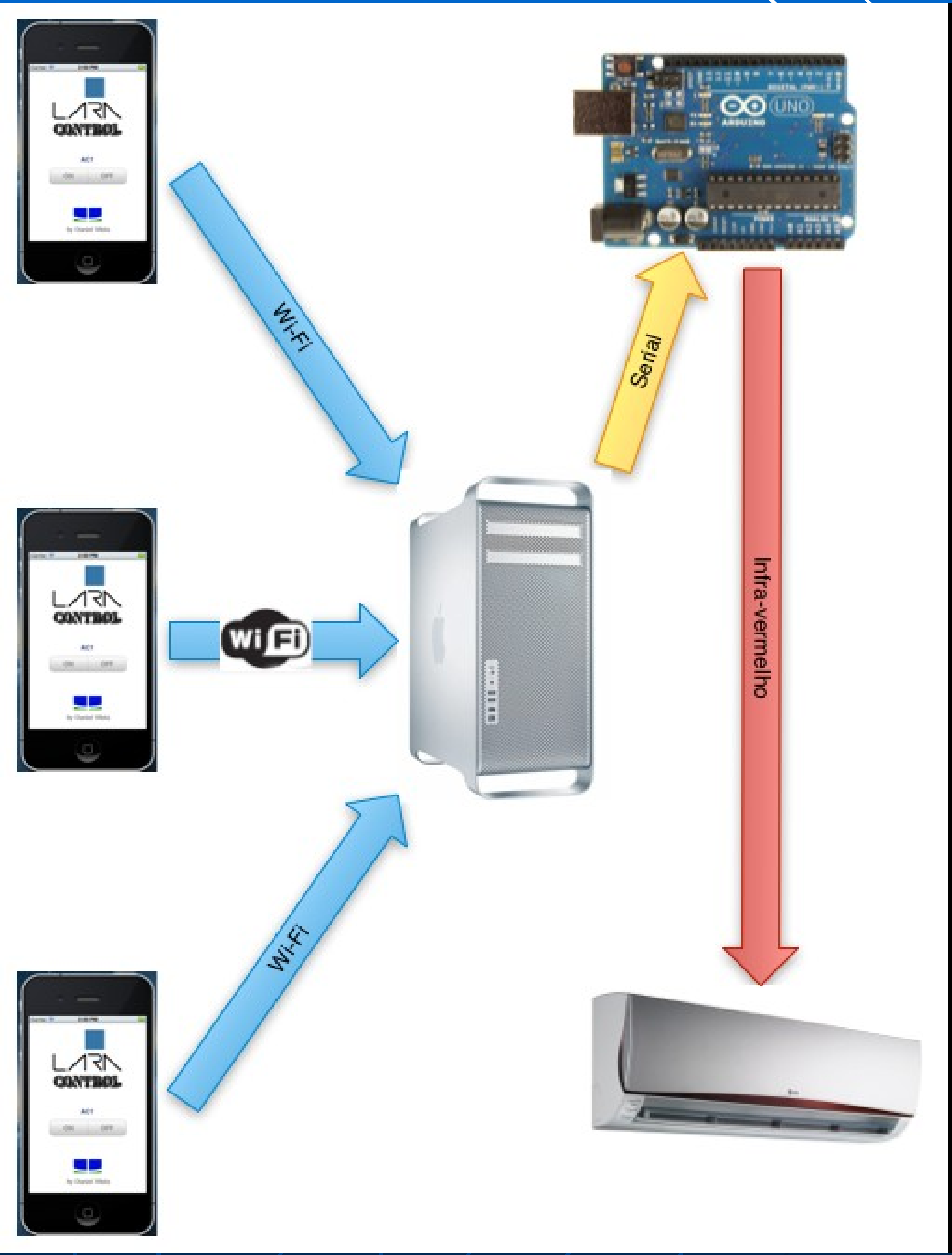


- On-Off controller
  - consumes the most energy
- PI controller
  - Has a better following of the set point (thermal comfort)
  - Slow to reach the set point
- Adaptive controller: model based building climatization:
  - Lowest energy consumption (quick pay back)
  - Good thermal comfort
  - Extra hardware and software necessary

Building Automation

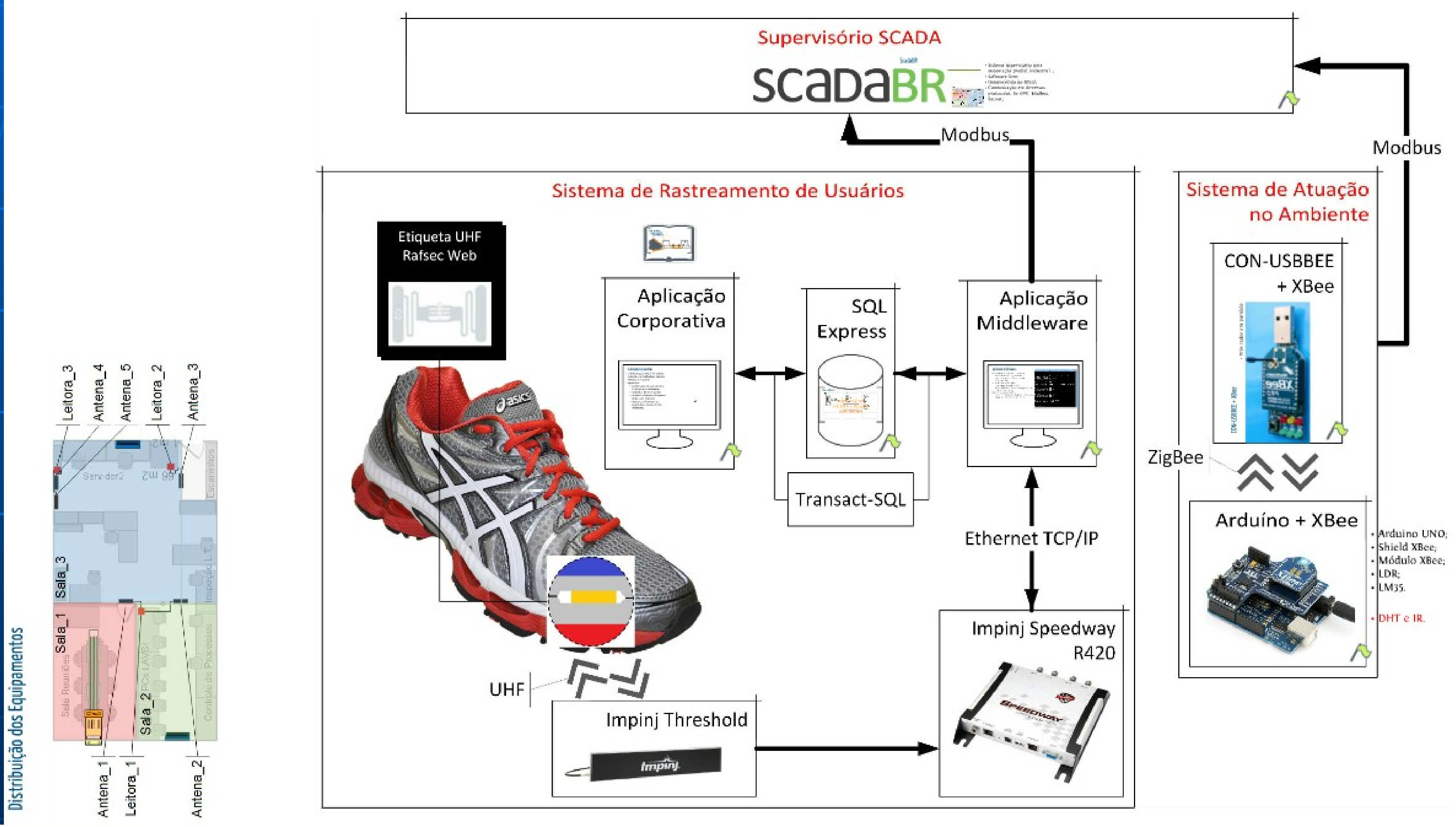
iPhone
WiFi
Arduino
ZigBee
Infra-Red
Split Air- Cond.

(Daniel Vilela, 2012)



Passive RFID user tracking in building automation

(Frederico Rocha e Filipe Oliveira, 2013)

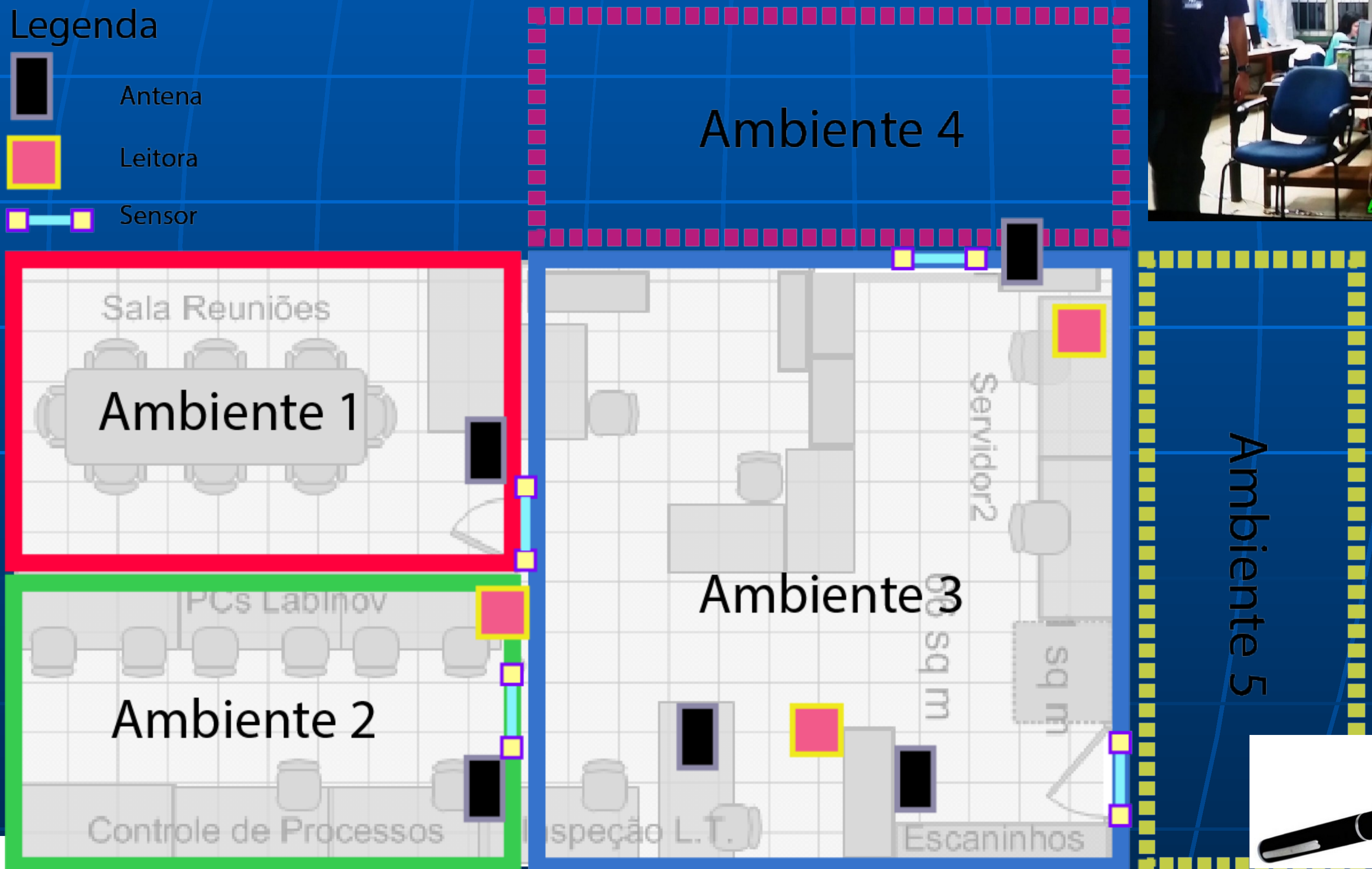


Occupancy by Passive RFID + Laser Beam

TG2015 Mecatrônica
Renata C.M. Chupel e Raissa A. Alves

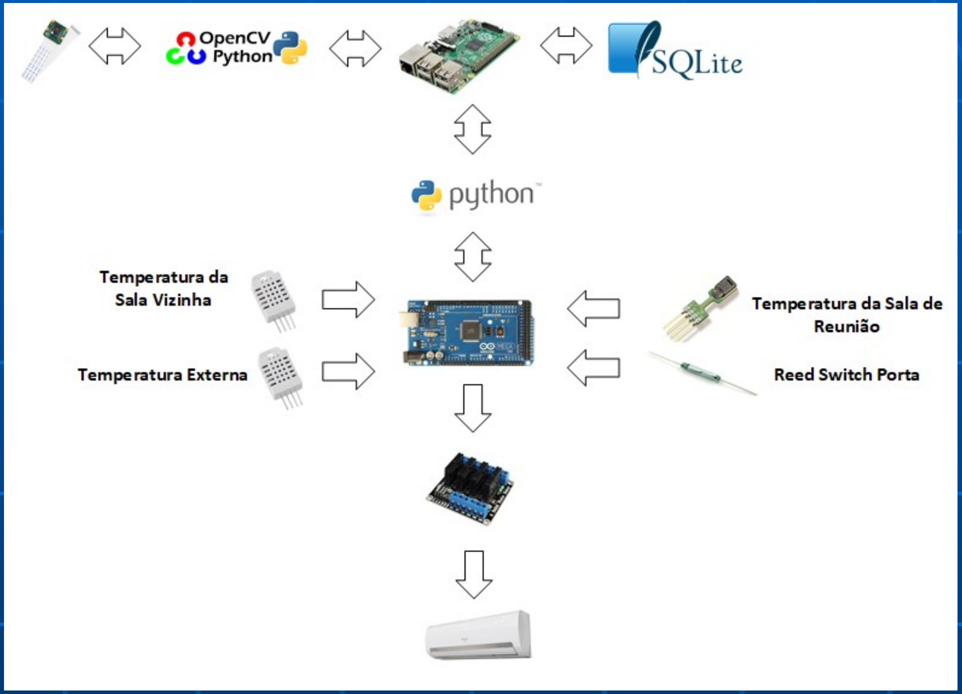
Legenda

- Antena
- Leitora
- Sensor



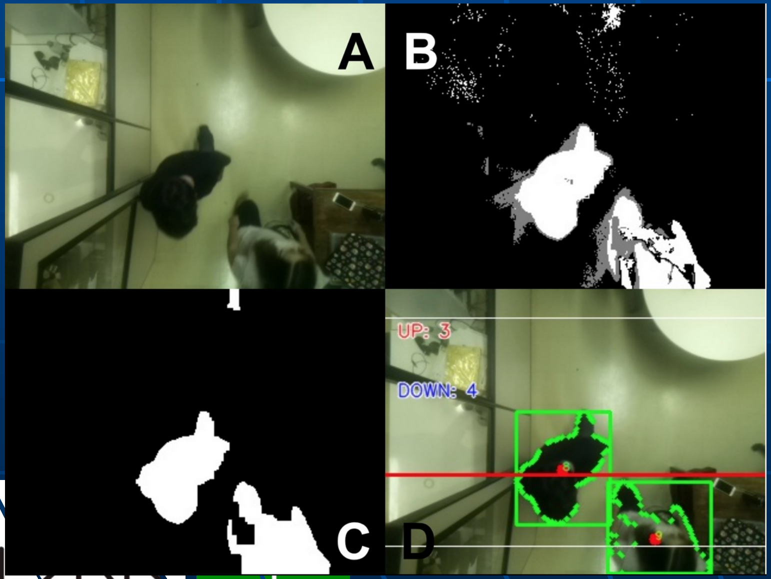
Controle Antecipativo por Estimativa da Carga Térmica em Vídeo

TG2018 Mecatrônica
Mariana Pimentel e Alexandre Saran



1 Pessoa 0,116 kWh

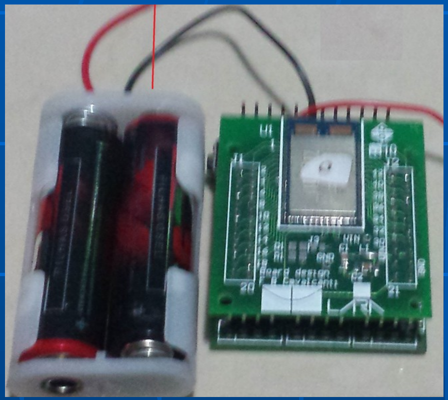
Contagem de Pessoas



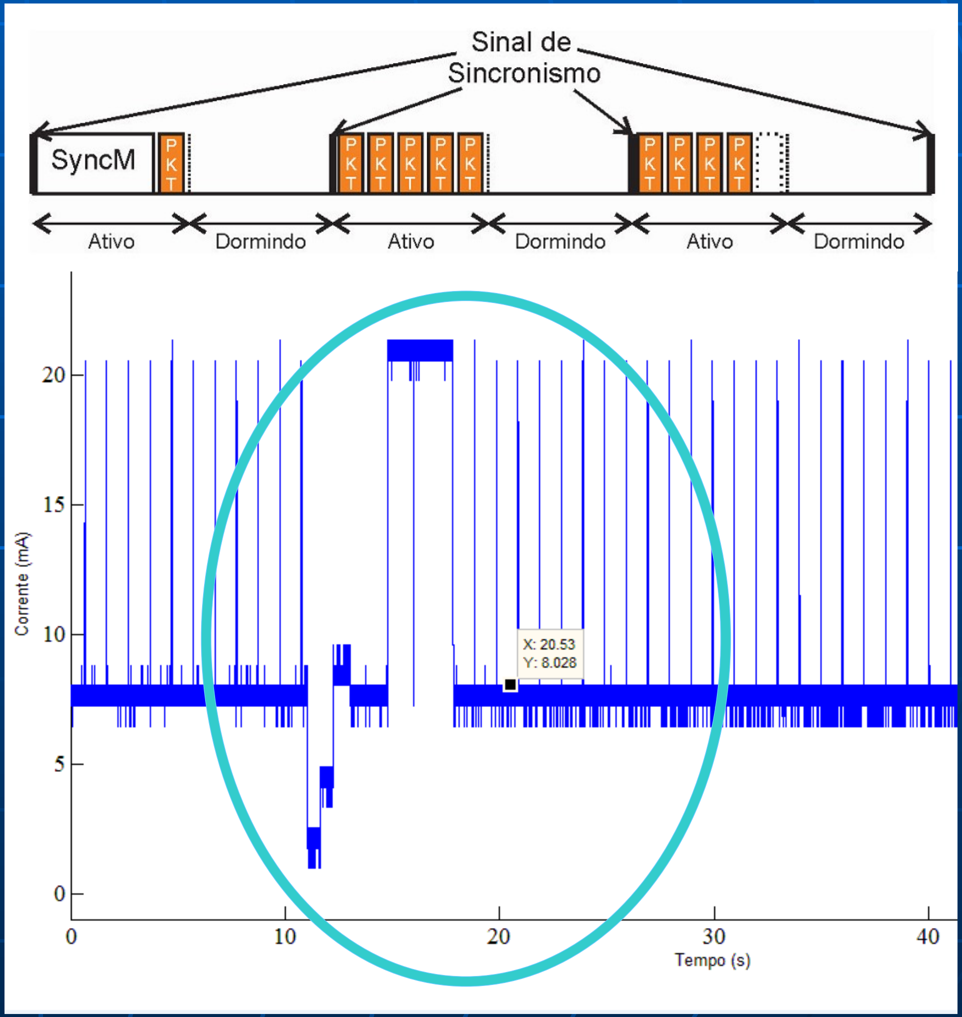
Controlador	Consumo	RMSE (Conforto)
Liga/Desliga	7,92 kWh	0,42
Antecipativo	5,81 kWh	0,37
Ganho %	26,64%	11,9%

DyTEE MAC/UnB – Dynamic Timed Energy Efficient

MSc Vinícius Guimarães, 2014



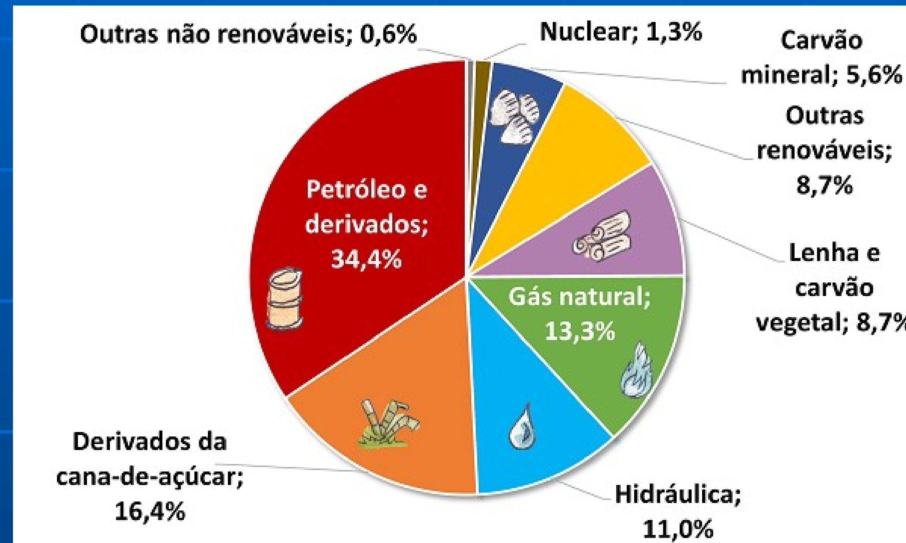
Sensor Node



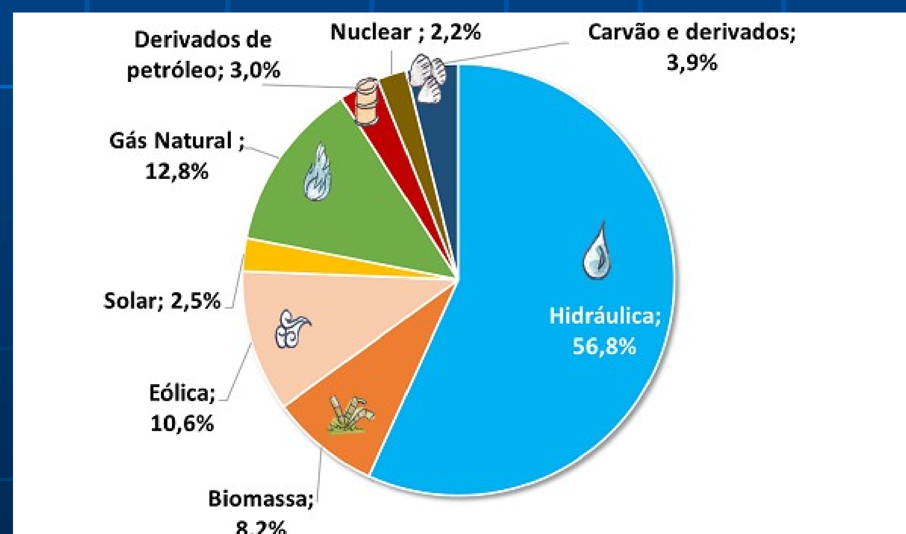
DyTEE

IEEE 802.15.4

Energy Efficiency - Labeling of Buildings



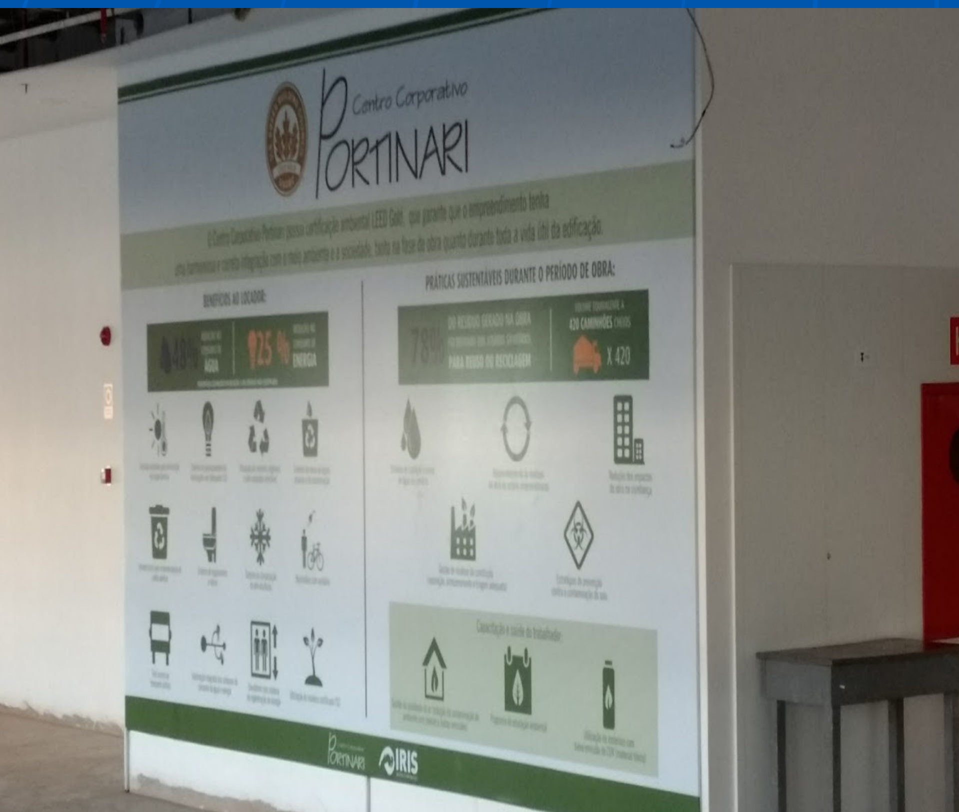
Matriz Energética Brasileira 2021

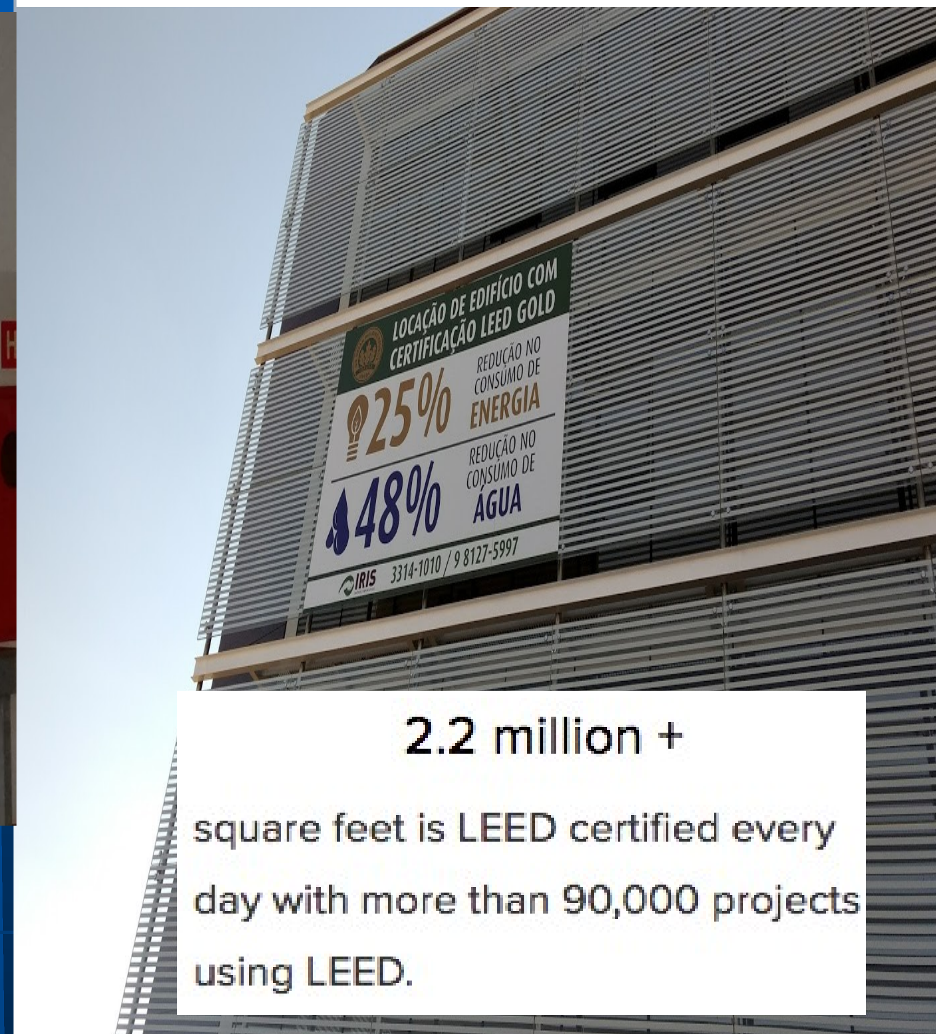


Matriz Elétrica Brasileira 2021

“Green Buildings”

“Green Buildings”



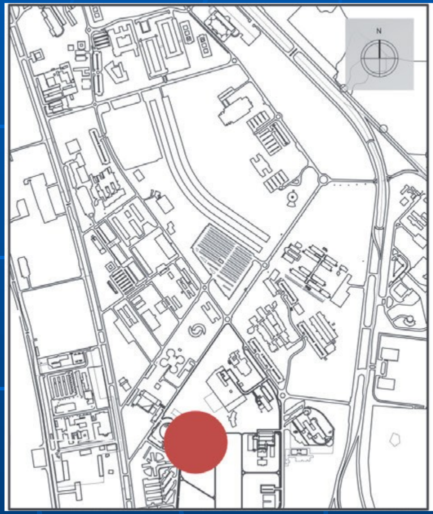


2.2 million +

square feet is LEED certified every day with more than 90,000 projects using LEED.

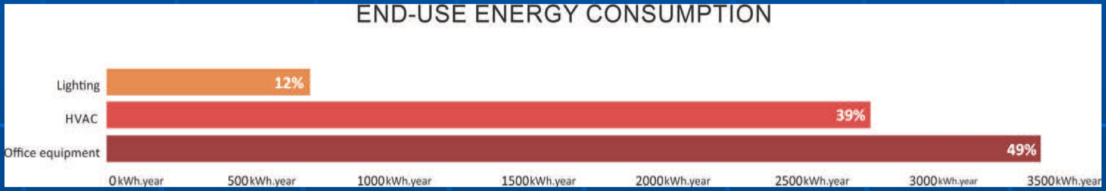
LabZero UnB – FAU/ENM/ENE

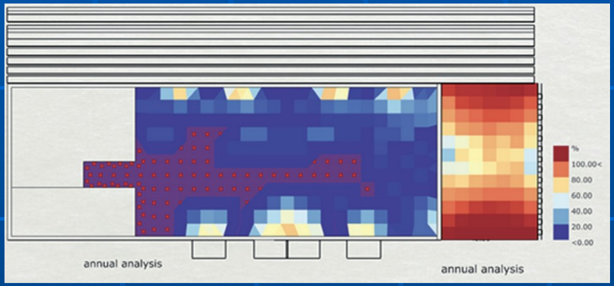
PROCEL Edifica Eletrobrás 2020



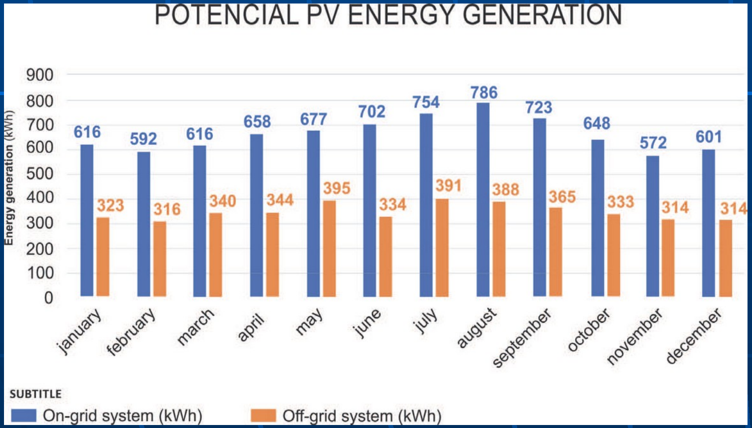
LabZero UnB – FAU/ENM/ENE

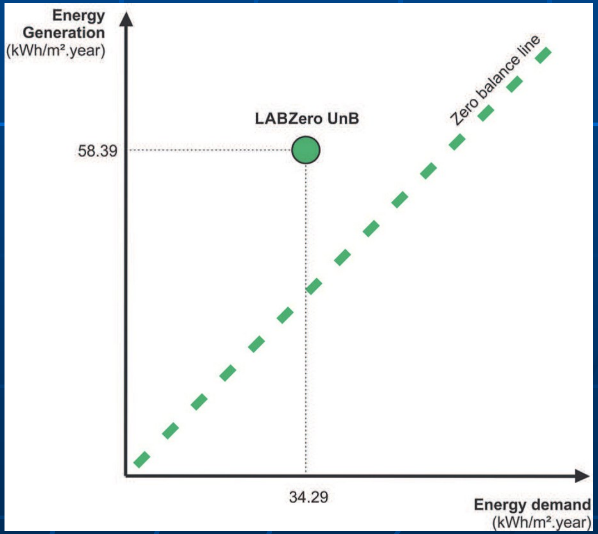
PROCEL Edifica Eletrobrás 2020





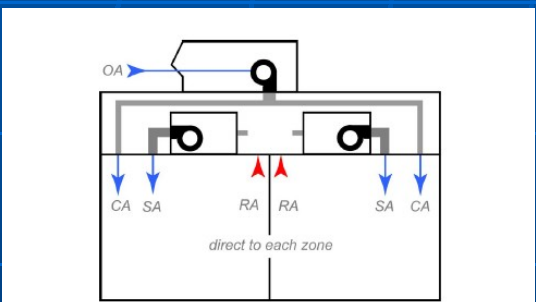
Useful daylight Illuminance (UDI) map above 2000 lux for the Coworking and balcony area

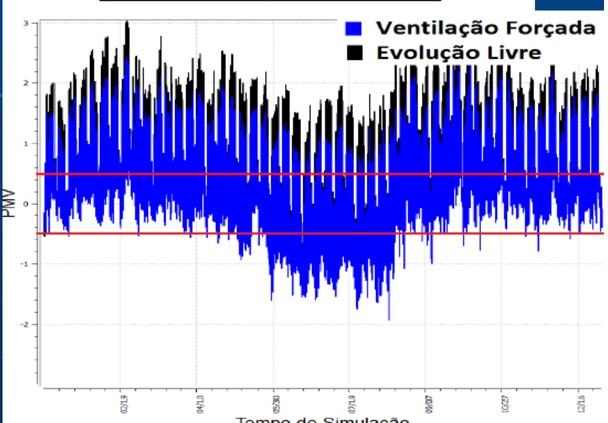


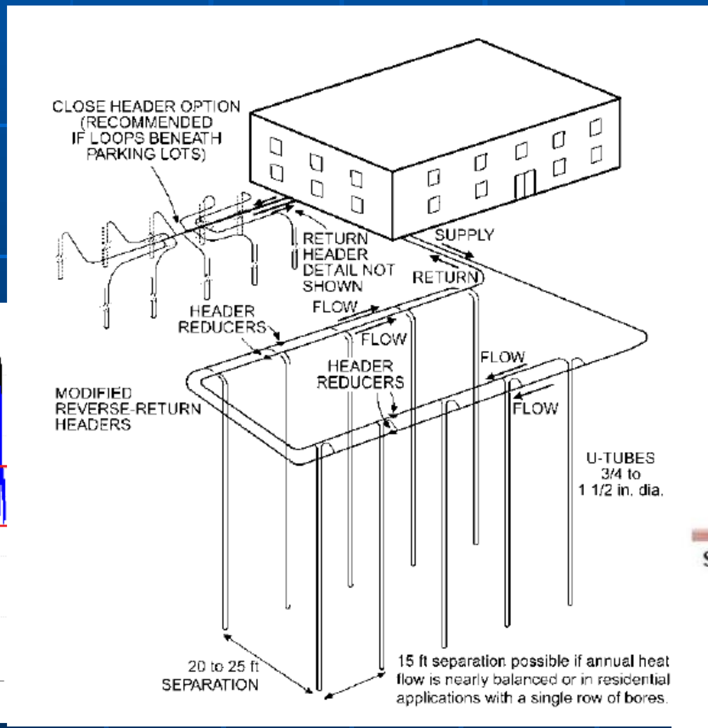


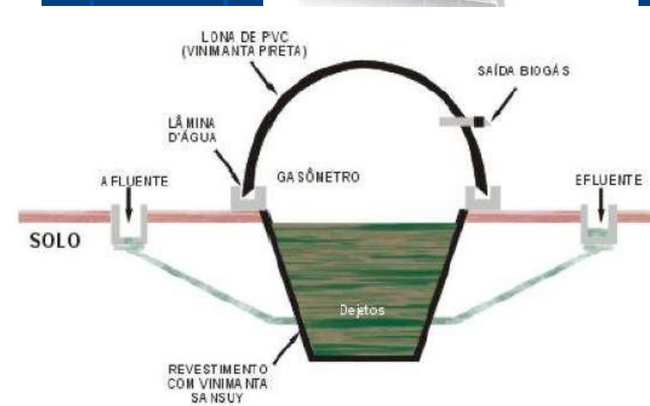
UnB nZEB Study

- Thermal Zone
- Forced Ventilation
- Solar colector
- Ground Heat
- Biogas
- Photovoltaic
- Dedicated Outdoor Air System









nZEB - UnB

CC - Estratégias energéticas

Legenda

01. Elementos de proteção solar calculados para cada fachada.

02. Melhor aproveitamento da iluminação e ventilação naturais.

03. Espaços verdes, que reduzem o efeito da ilha de calor.

04. Elevada inércia térmica das fachadas.

05. Utilização de placas fotovoltaicas, para geração de energia.

06. Captação de águas pluviais.

07 e 08. Utilização da chaminé térmica (7) aliada ao poço provençal (8), para diminuir a demanda energética do edifício.

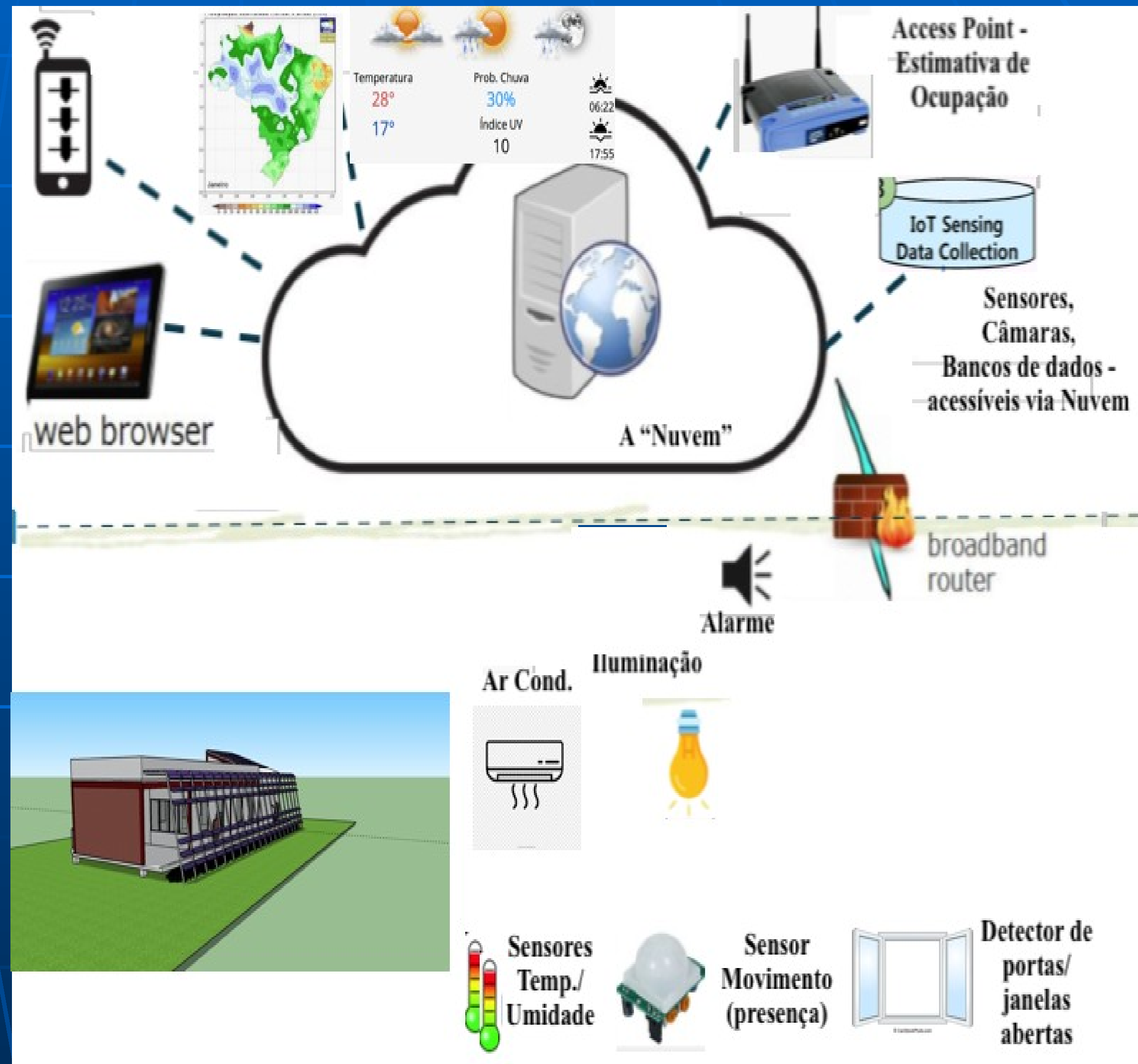
09. Resfriamento noturno: criação de aberturas próximas a massa da laje.

LabZero UnB Automação IoT

- Visão Geral

  Divulgação da Eficiência Energética do prédio nZEB como IoT na Nuvem

- Supervisório com séries temporais relevantes



LabZero UnB
Automação IoT com ESP32

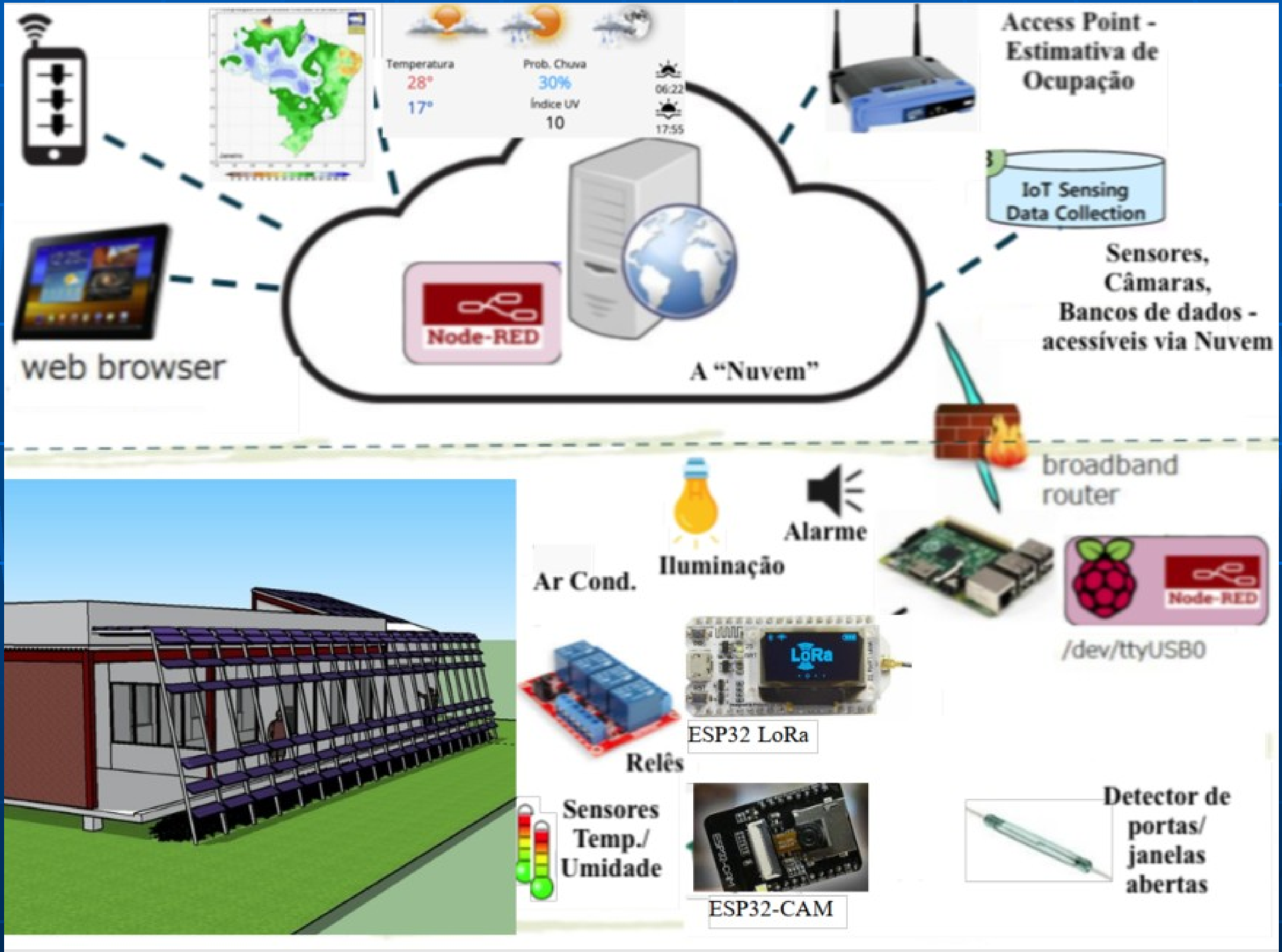
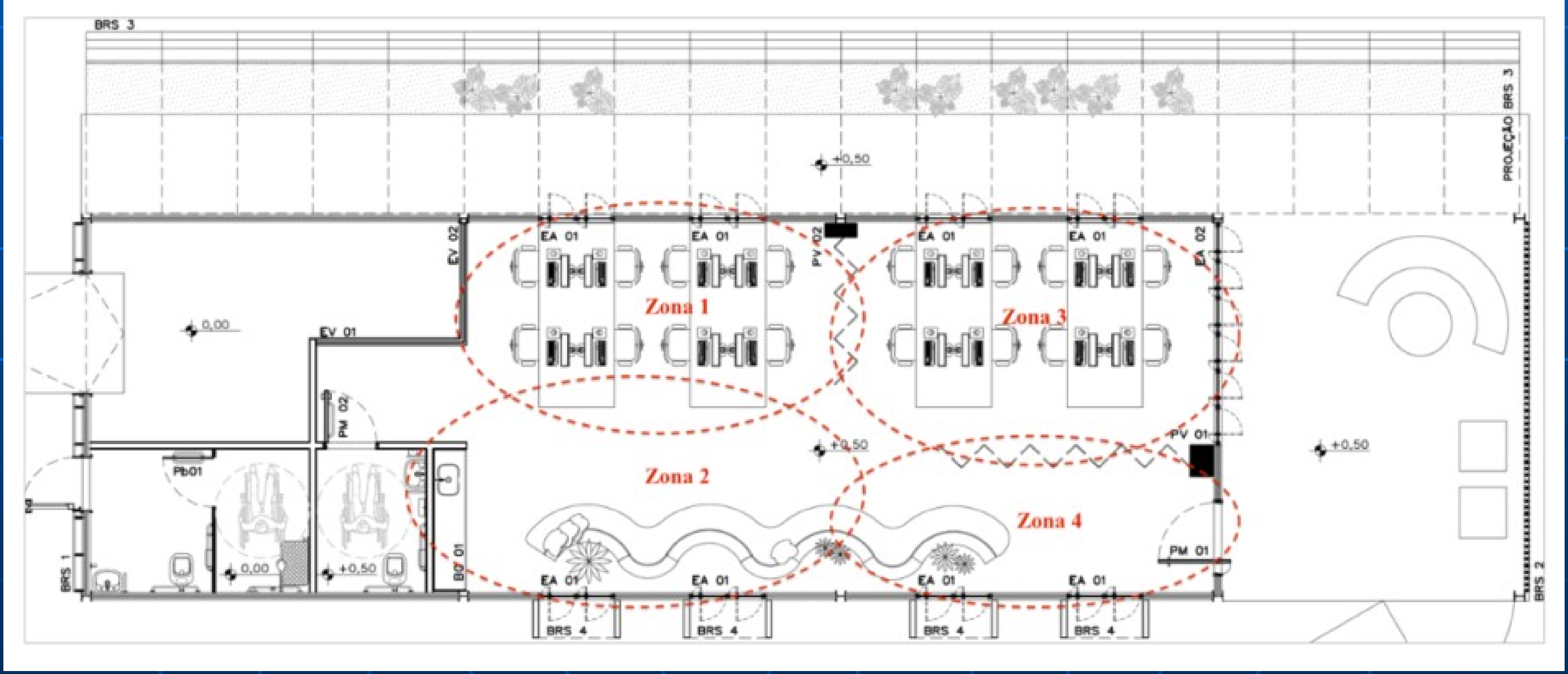


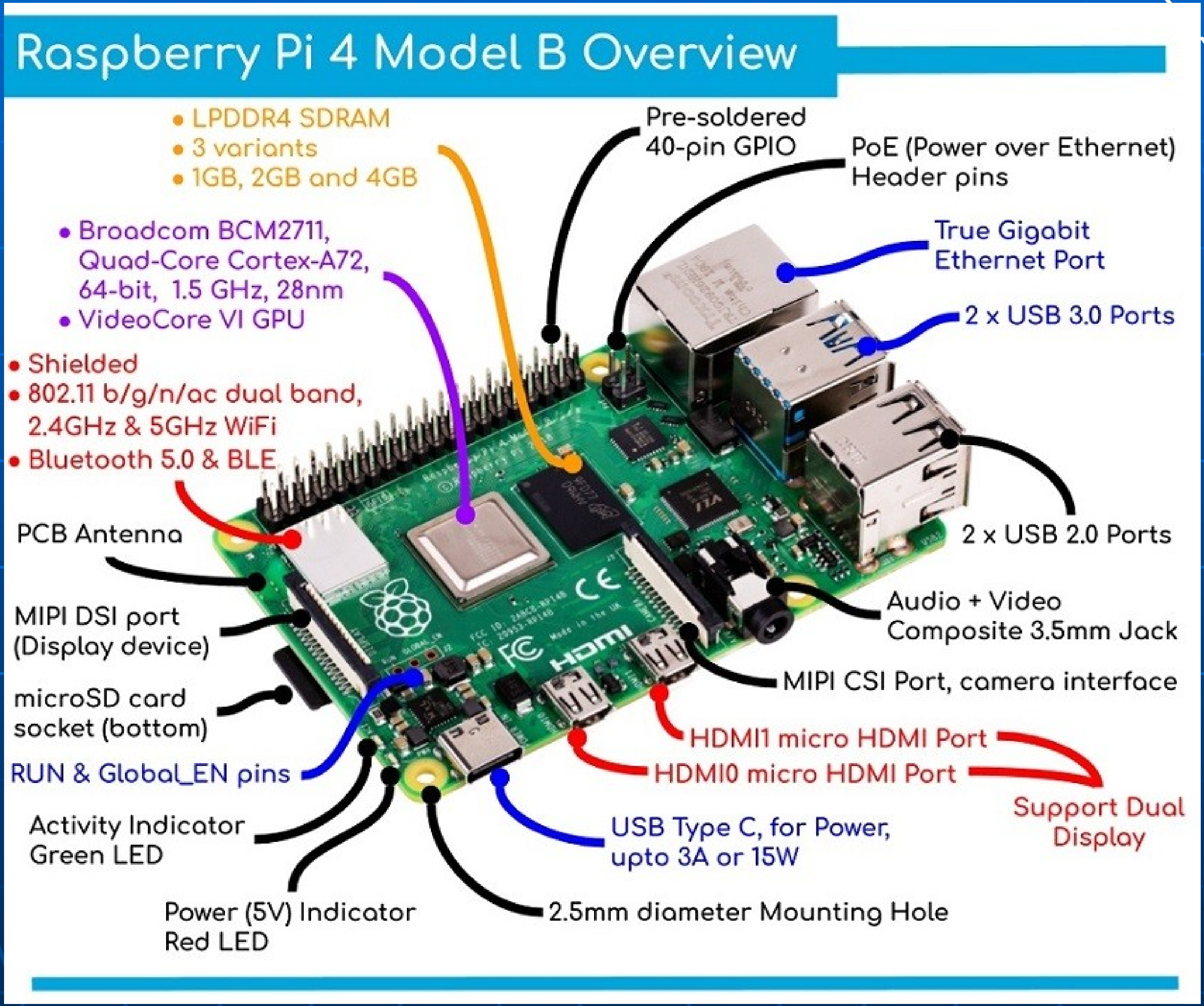
Figura 3.4.1 – **Visão geral da automação do projeto Co-Working ZEB UnB.**

Conforto Multi-Zonas com carga térmica compartilhada

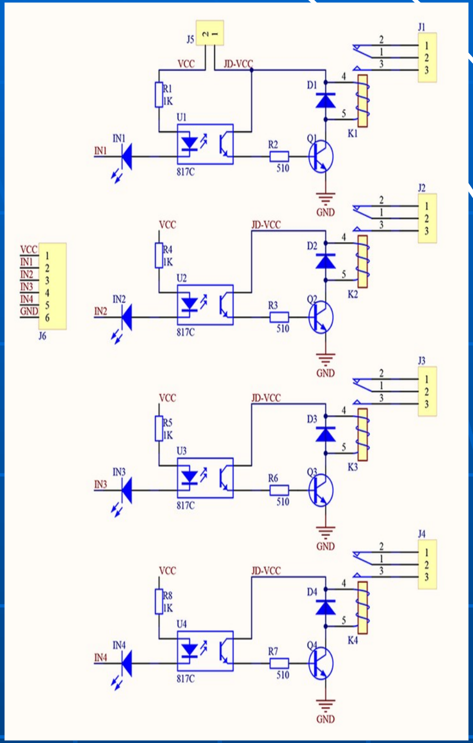


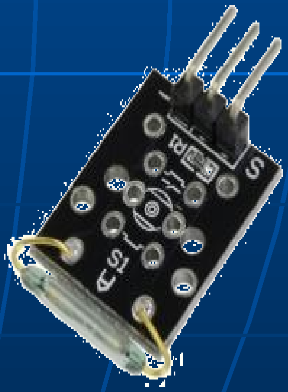
Placa WiFi ESP32 + LoRa; ESP32-CAM

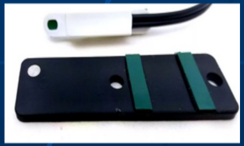
Figura 3.4.3 – No sentido horário: Placa WiFi ESP32 + LoRa; ESP32-CAM, Case, Case c/ antena LORA.


Raspberry Pi 4 Model B Overview
• LPDDR4 SDRAM
• 3 variants
• 1GB, 2GB and 4GB
Pre-soldered 40-pin GPIO
PoE (Power over Ethernet) Header pins
• Broadcom BCM2711, Quad-Core Cortex-A72, 64-bit, 1.5 GHz, 28nm
• VideoCore VI GPU
True Gigabit Ethernet Port
2 x USB 3.0 Ports
• Shielded
• 802.11 b/g/n/ac dual band, 2.4GHz & 5GHz WiFi
• Bluetooth 5.0 & BLE
PCB Antenna
2 x USB 2.0 Ports
MIPI DSI port (Display device)
Audio + Video Composite 3.5mm Jack
microSD card socket (bottom)
MIPI CSI Port, camera interface
HDMI1 micro HDMI Port
HDMI0 micro HDMI Port
RUN & Global_EN pins
Support Dual Display
Activity Indicator Green LED
USB Type C, for Power, upto 3A or 15W
Power (5V) Indicator Red LED
2.5mm diameter Mounting Hole

Sensores e Atuadores



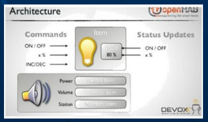




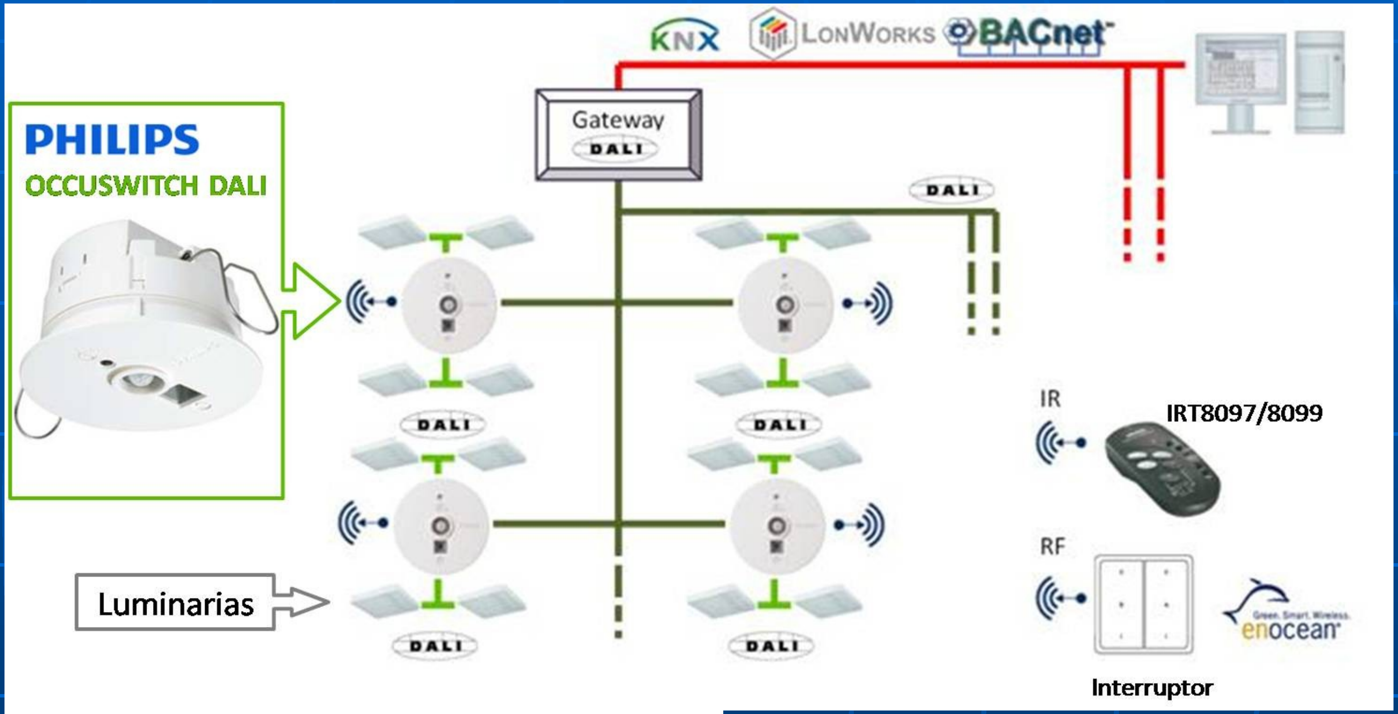
DHT22
Umidade +
Temperatura

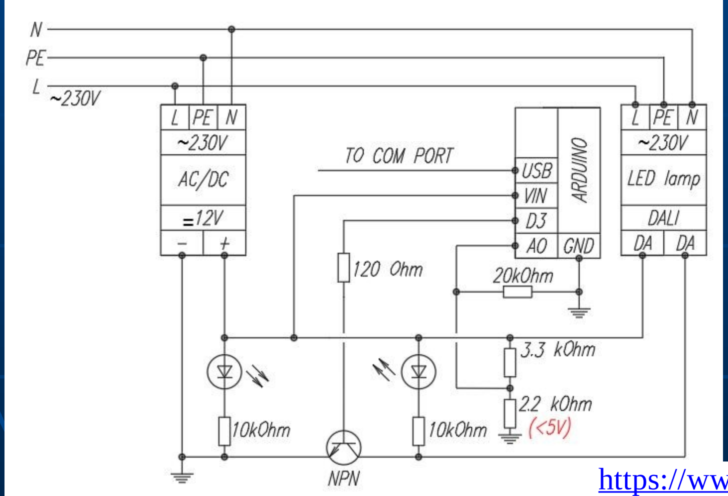
ESP32 + 4x (Optoacoplador + Relé)

Reed Switch – contato magnético



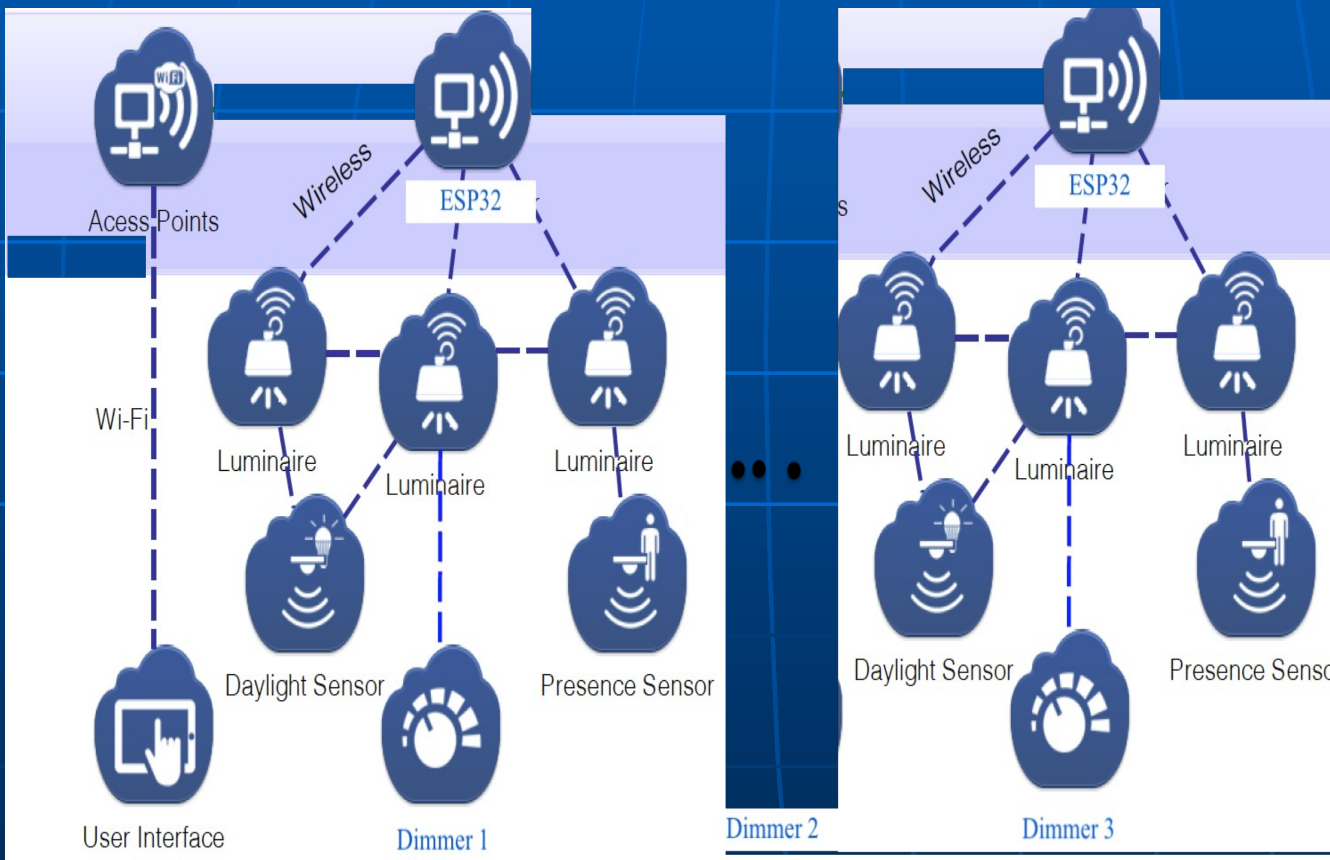
Luminárias dimerizáveis

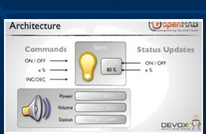




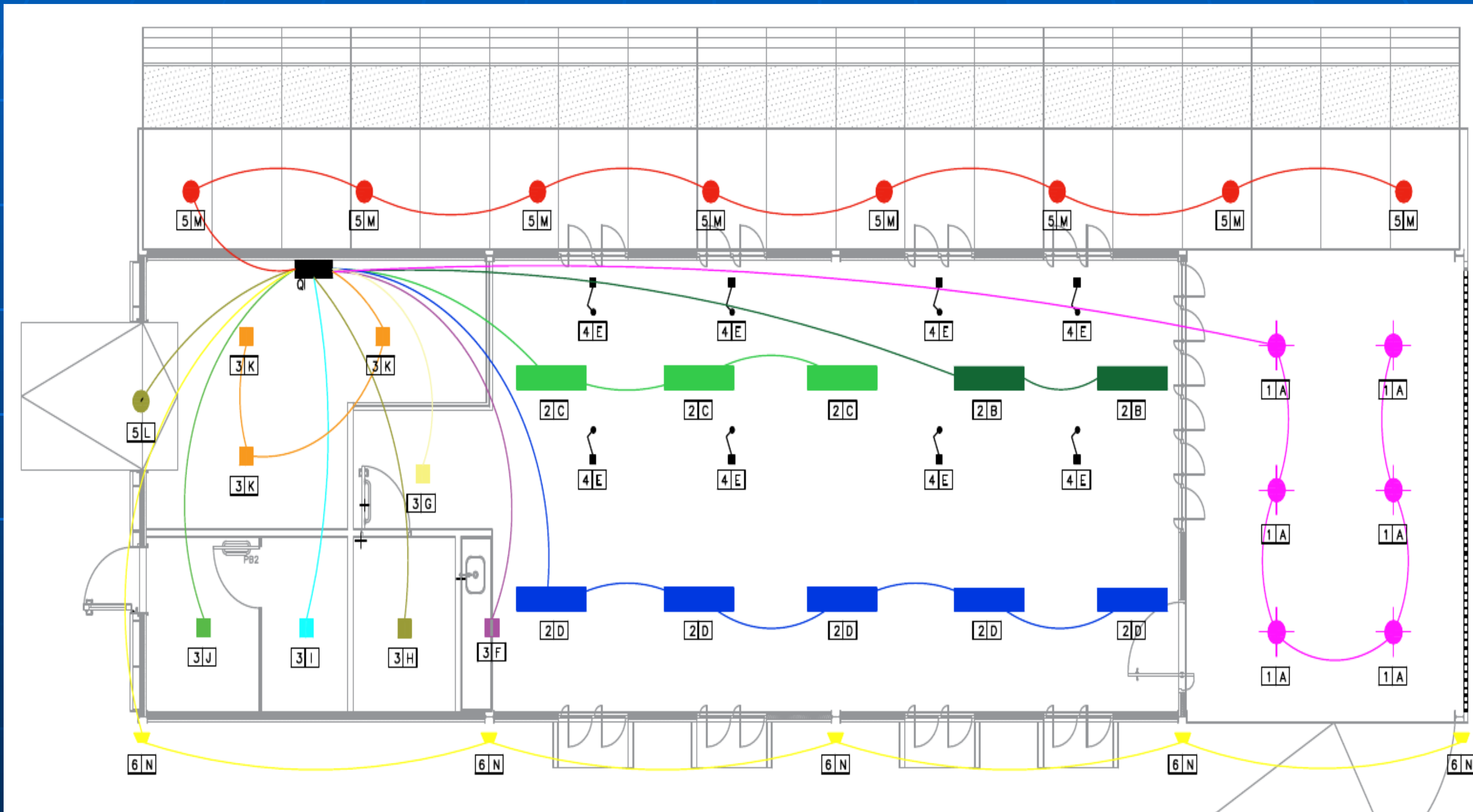
https://www.hackster.io/NabiyevTR/simple-dali-controller-506e44

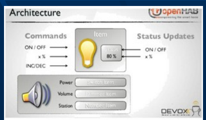
Dimmerizable Illumination (WiFi) - e.g.: ZigBee/BLE/Lora





NZEB Circuitos Luminotécnicos



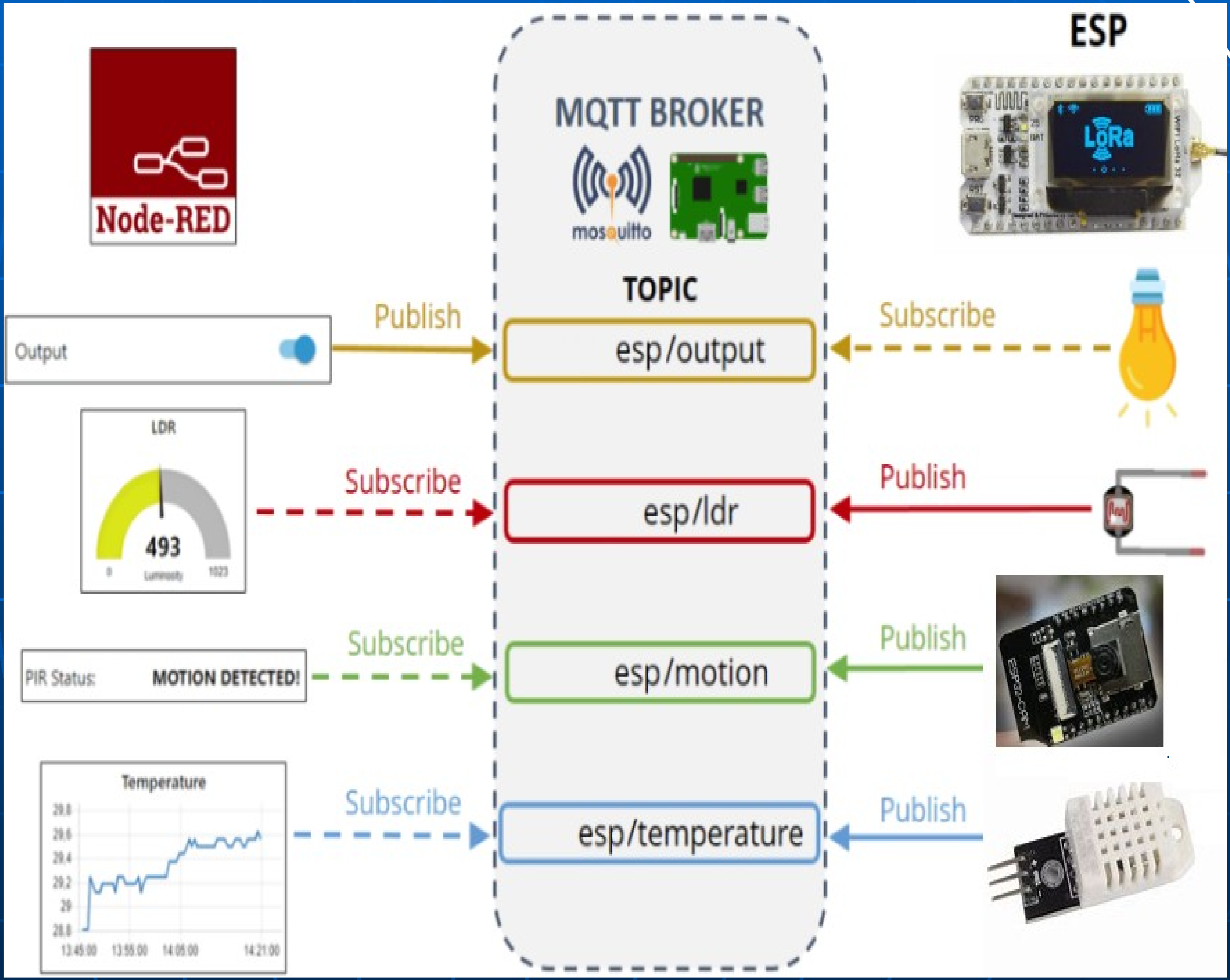


Automação LabZero – sinais (pontos)

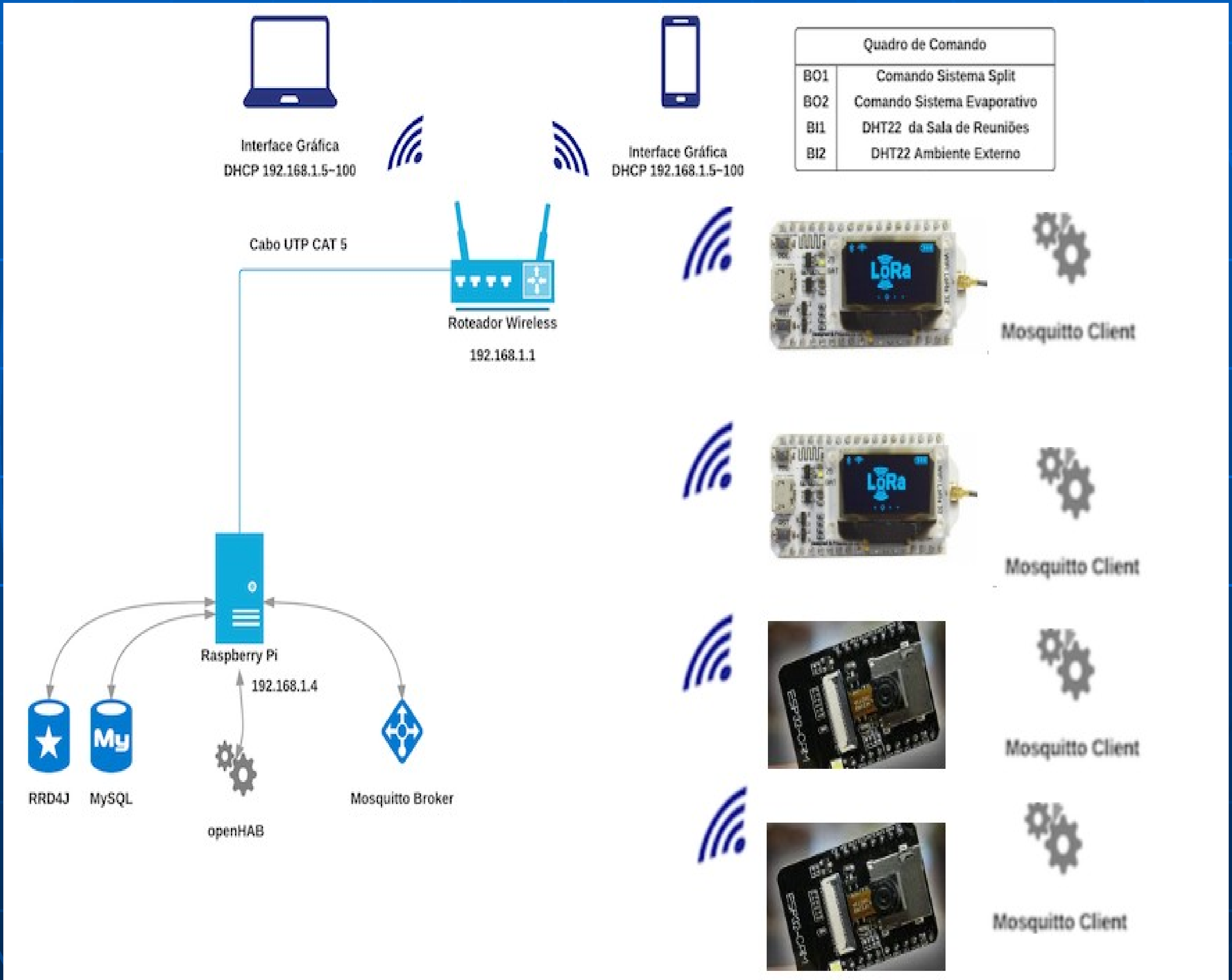
SDCD	Pontos	Tipo	Descrição
Conforto/ Energia ESP32-CAM + Rasp. Pi	TT11- TTI8	AI	Temperatura DHT22 posições 11 a 18
	MT11-MT18	AI	Umidade Relativa DHT22 posições 11 a 18
	ANI11-AN13	AI	Anemômetro posições 11 a 13
	LXI11-LX13	AI	Sensor de Luminosidade posições 11 a 13
	LXC11-LXC13	AO	Comando de Luminosidade posições 1 a 3
	JX71-JX75	AI	Medidores de Energia: JC compressor, JV ventilação, JE evaporativo, JI iluminação, JD, demais cargas
Iluminação ESP32	DI11-DI13	DI	Presença - Câmera nas posições 11, 12 13 e 14 (Número de pessoas por zona)
	DI21-D47	BI	Sensor de porta/janela aberta “Reed Switch”
HVAC Rasp. Pi	VF1-VF4	AI	Consumo Energia: CD EV Vent Evap
	D01-D02	BO	Válvulas R1 e R2
	D03-D04	BO	Posição da Válvula V1 (duas posições – Evaporativo e Sgeo
	DO5	BO	Acionamento Liga/Desliga Bomba D’água
HVAC Rasp. P	W01	AI	Energia Fotovoltaica Gerada
	W02	AI	Energia Elétrica LabZero Consumida

Medição do consumo de energia iluminação: Zonas + “demais”

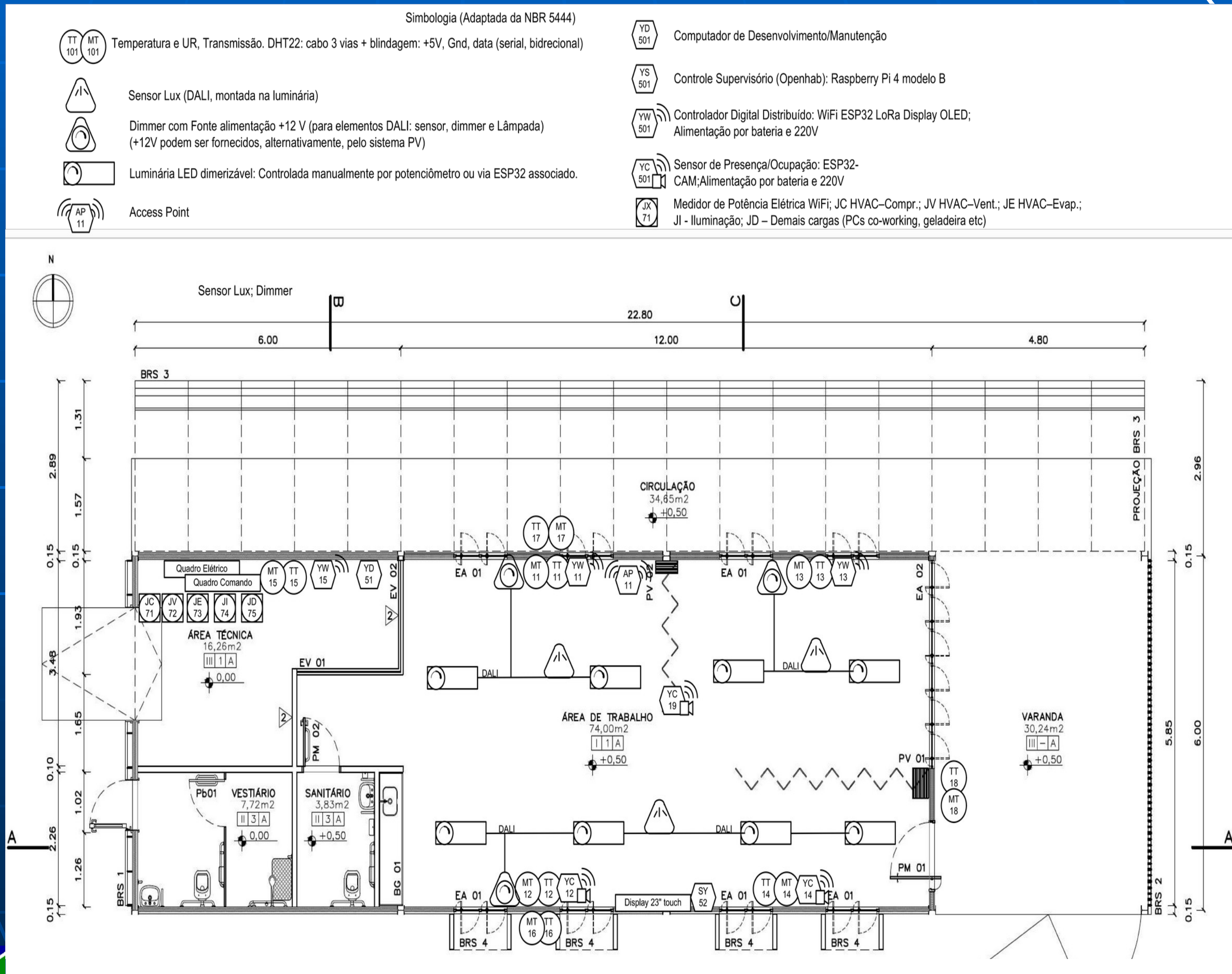
Fluxo da informação no nZEB



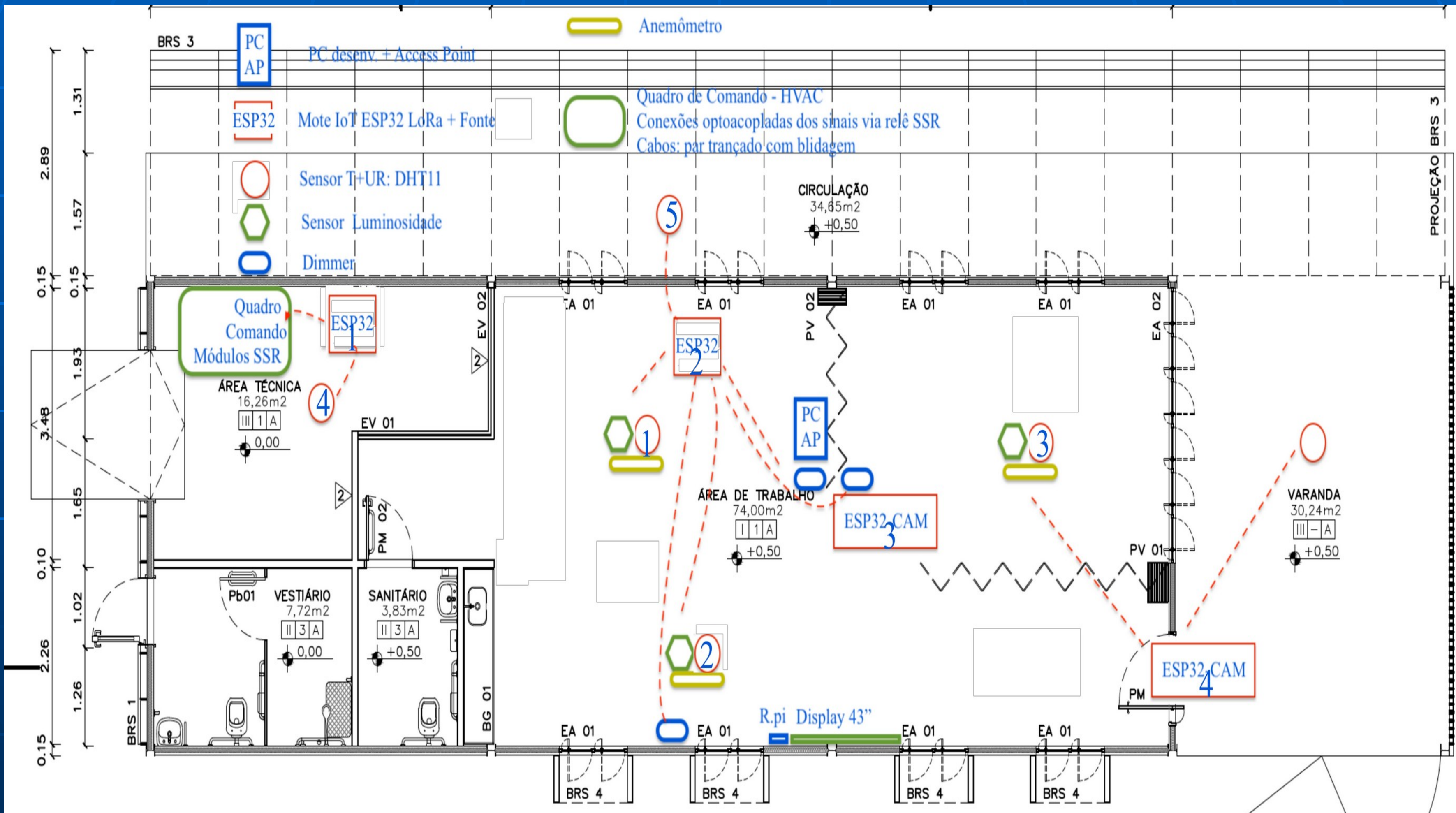
Acesso externo ("Nuvem") no nZEB



NZEB – Projeto de Automação (adapt. NBR5444)

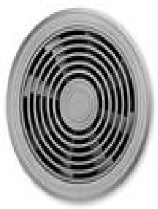


NZEB – Projeto de Automação ("com cores")

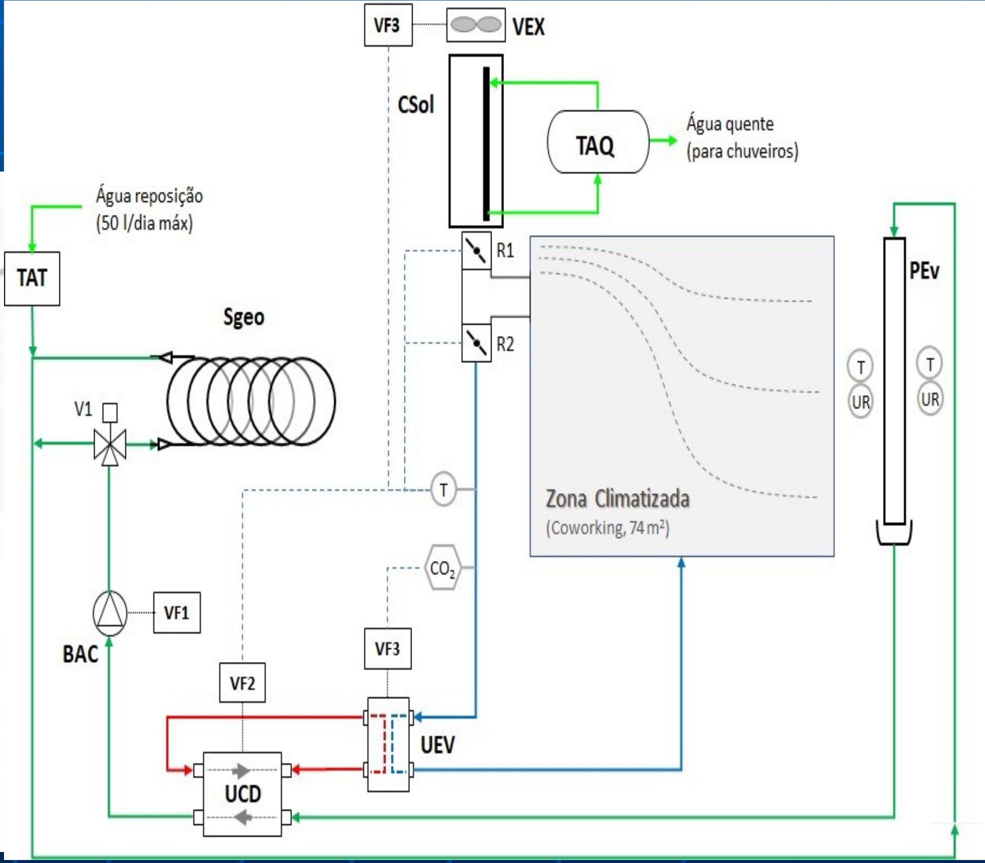


HVAC - LabZero UnB

1. Ventilação natural + chaminé solar/ (passiva);
2. Ventilação Forçada + chaminé solar (VentFor) /(ativa);
3. Refrigeração mecânica (RefMec)/ (ativa);
4. Em complemento, e somente na área da varanda, Resfriamento Evaporativo (ResEvap)/(ativa)

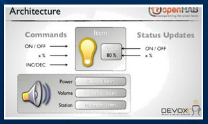


RPI24AP



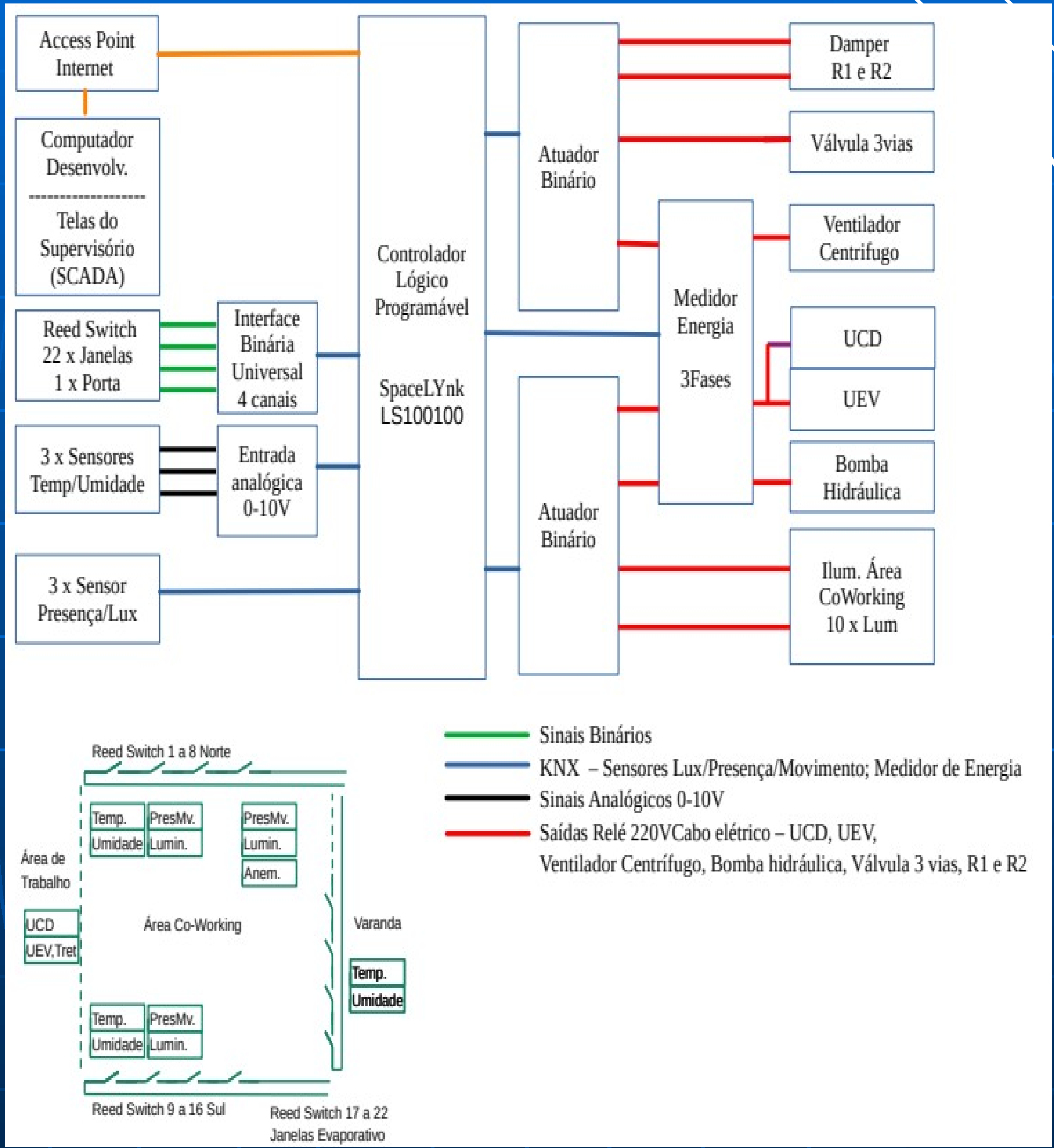
18 x difusores de piso
Condensadora Split Acqua
Evaporadora Split New Utopia HFC
4 x Ventiladores Centrifugos

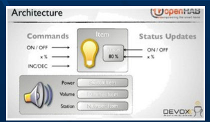
GR22V-4IP.Z8.AR ventilador centrifugo



Automação Predial IoT

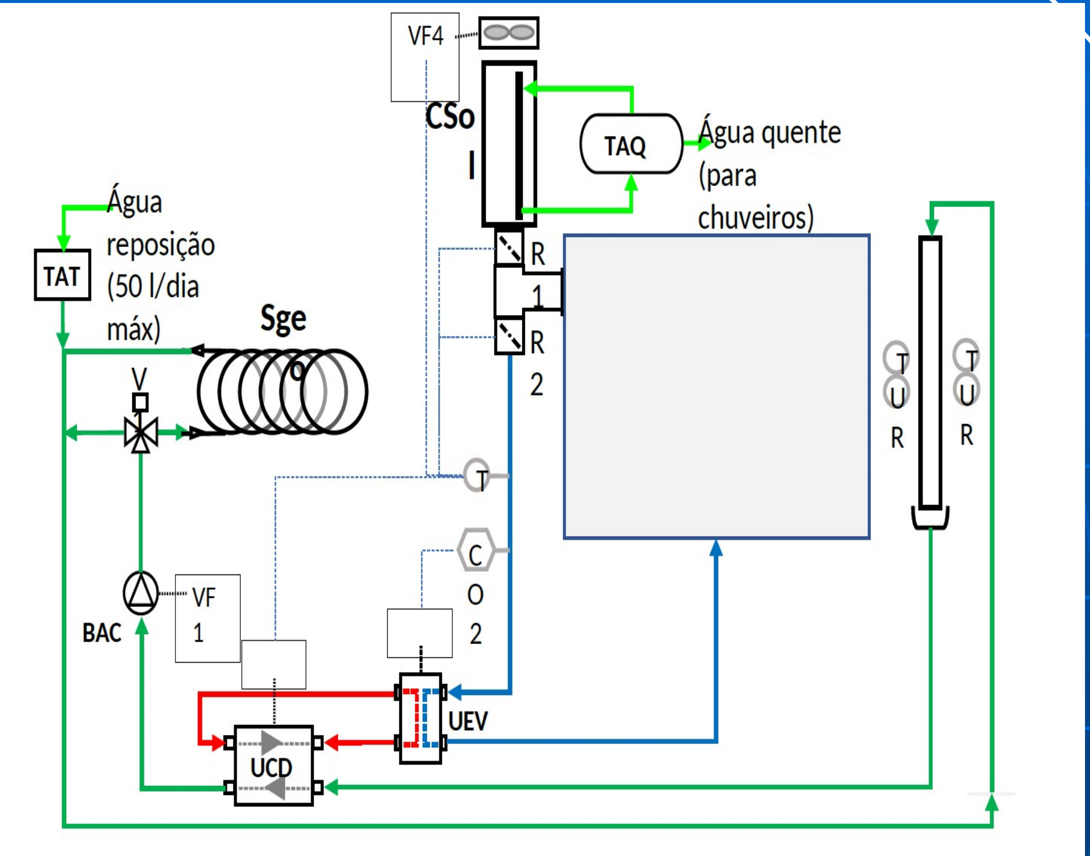
- Barramento KNX
- Controlador Lógico Programável SpaceLYnk
- também é Supervisório
- - Telas Mímico
  - Séries Temporais
-





Automação Predial IoT

- Ar-Condicionado
- Faixas de trabalho para a comutação entre os modos o ar condicionado
- → a definir!

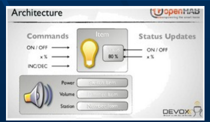


	I	II	III	IV
R1	OPEN	OPEN	OPEN	CLOSED
R2	CLOSED	CLOSED	CLOSED	OPEN
VEX	OFF	ON	ON / OFF	OFF
UCD/ UEV	OFF	OFF	OFF	ON
V1	*	*	OPEN A	OPEN A/B
BAC	OFF	OFF	ON	ON

I : Ventilação Induzida (VI, chaminé solar)
II: Ventilação Forçada (VF)
III: VI/VF + Cobogó Evaporativo (REV)
IV: Sistema Split (REF)

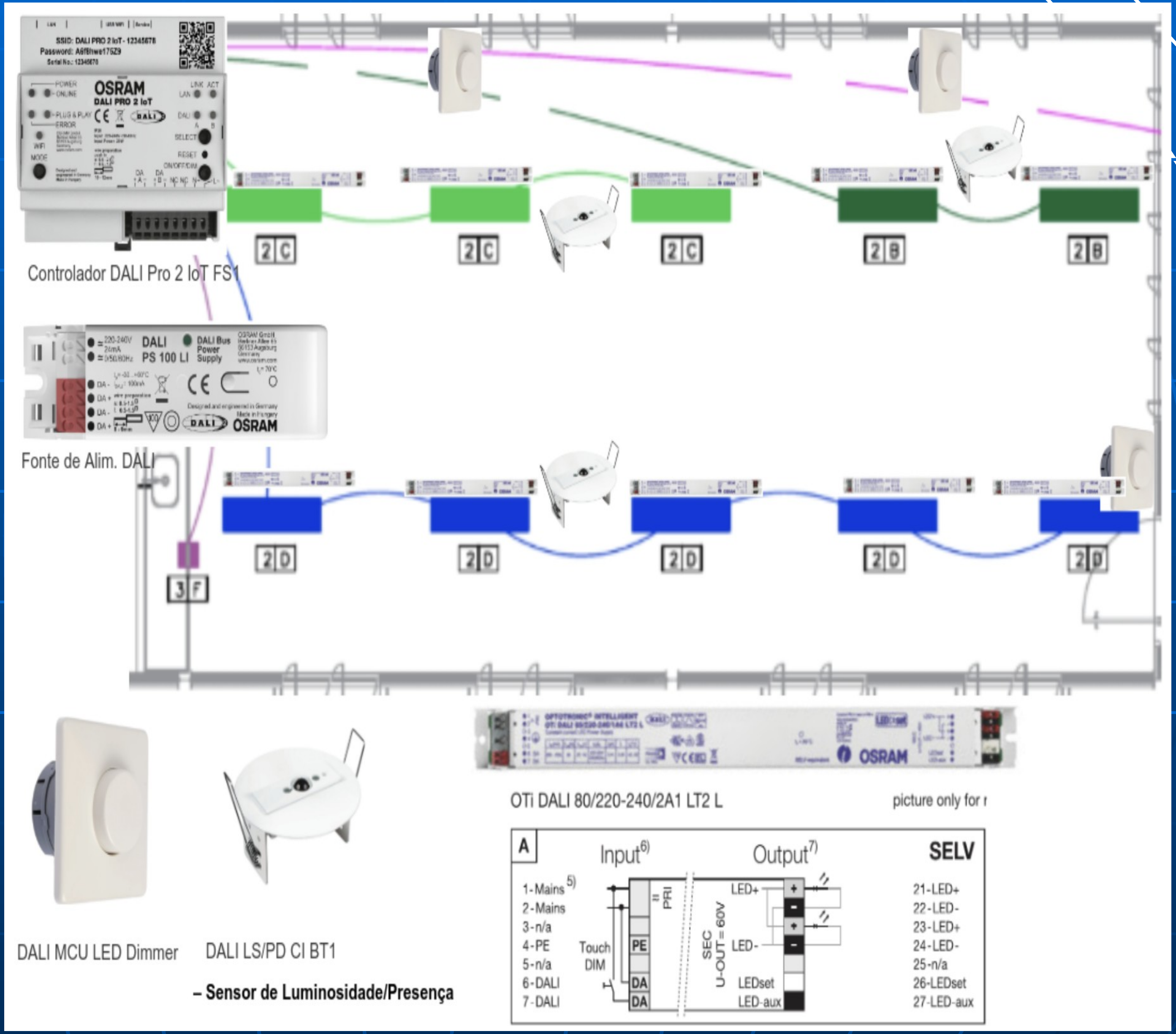
Uma vez ativado cada modo de operação, o controle é feito sobre as vazões de ar, água e refrigerante, por meio dos variadores de frequência (VF1 a VF4) em função do conforto e qualidade do ar no ambiente.

* Indiferente



Automação Predial IoT

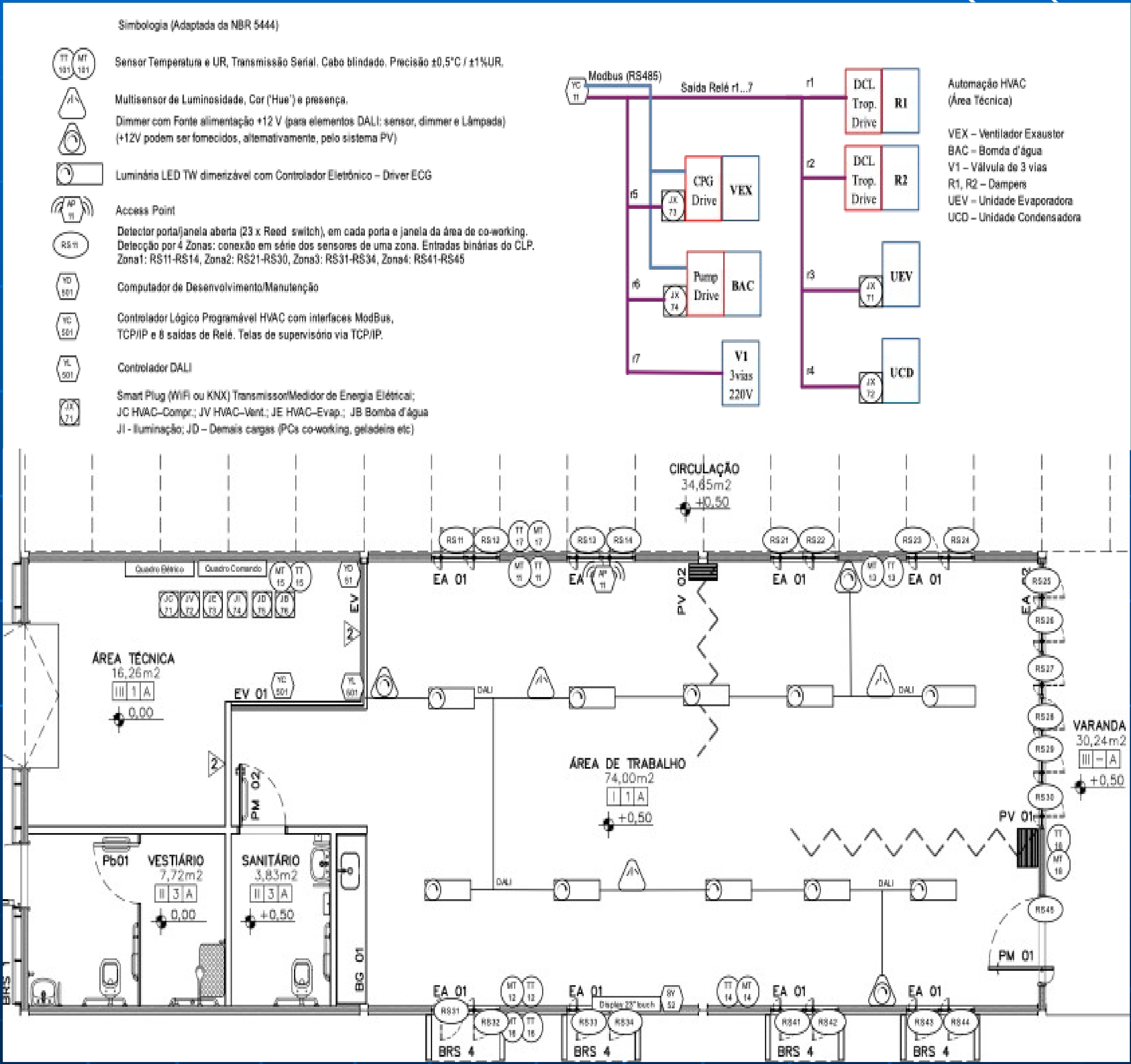
- Iluminação
- DALI

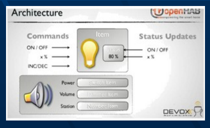


Automação Predial IoT

- Alocação
- Física
- dos Dispositivos
- de Automação

- Adaptado
- NBR 5444

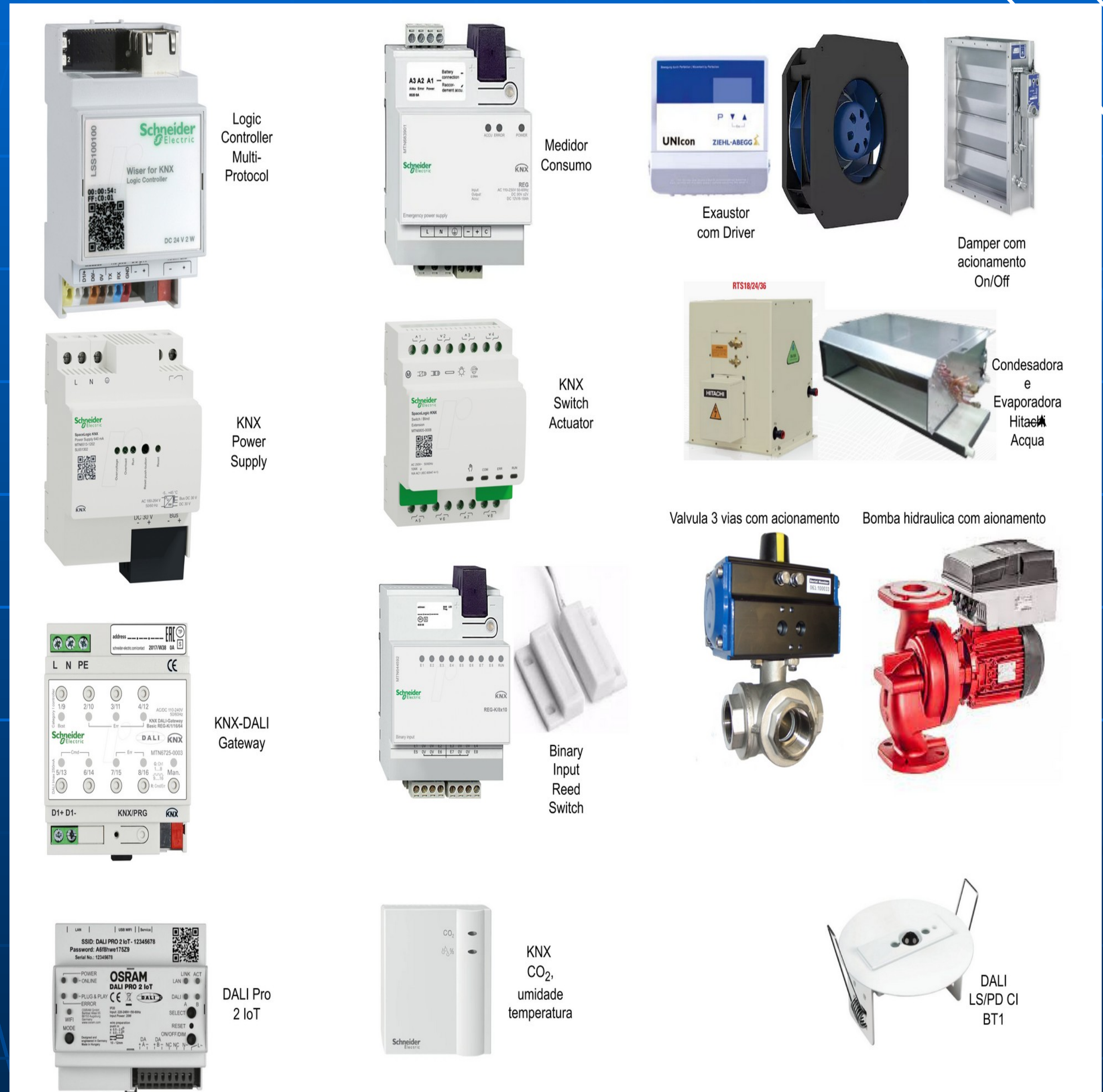


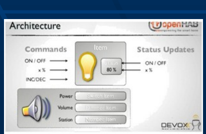


Automação Predial IoT

- Dispositivos
- de Automação

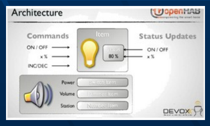
- KNX





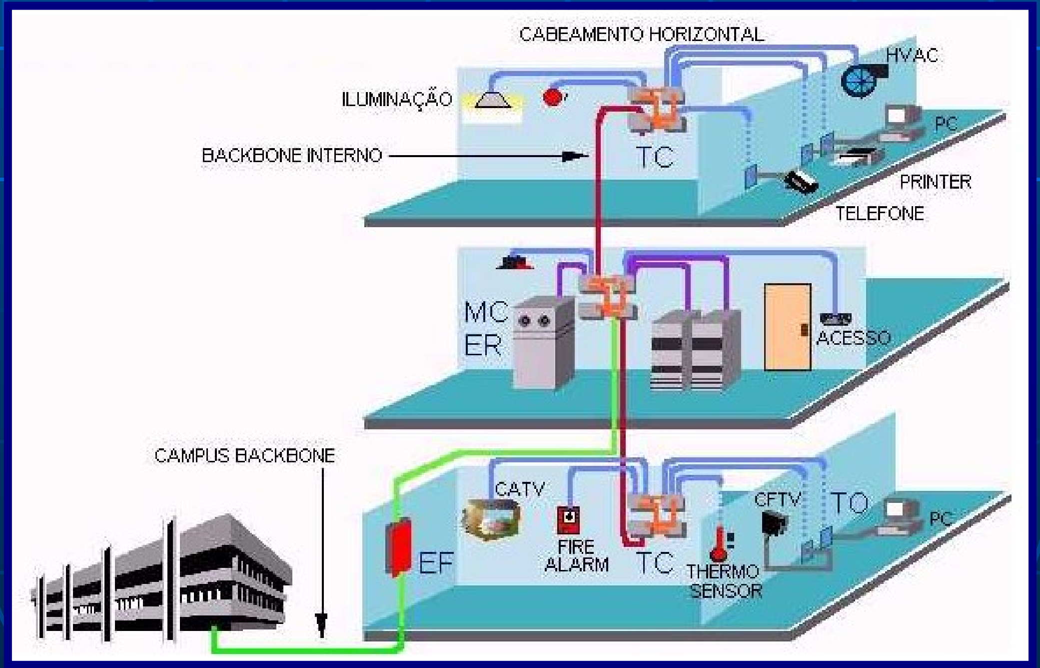
Building Automation – Where to work

- Design
- Specification
- Execution
- Supervision
- Comissioning
- Operation
- Maintanance
- Consulting



The “near” future

- Energy Efficiency Labeling of Buildings
- nearly Zero Energy Building - nZEB
- Assisted Living
- Smart Cities
- Digitals Twin



Thank You!

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