

**DOMOTICS RELATED TO ENERGY
AND R.E.S. MANAGEMENT:
A CASE STUDY HOW TO INNOVATE
ON THE POWER CONSUMPTION &
MANAGEMENT IN BUILDINGS**

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ABOUT TRANSILVANIA UNIVERSITY



Brasov Romania city mentioned from 1241 as German city
Geographic coordinates: **45.6528° N, 25.6119° E**
Actually number of inhabitants:

Transilvania University History:

1940 First HE institution Academy of Trade and Industrial Studies.
1948 The Silviculture Institute is set up.
1949 The Mechanical Institute is set up
1971 **The University of Brasov** is born through the merger of the Polytechnic and Pedagogical Institutes.
1991 **University of Brasov's** Senate decided to change the name of the university that



TRANSILVANIA UNIVERSITY CAMPUS

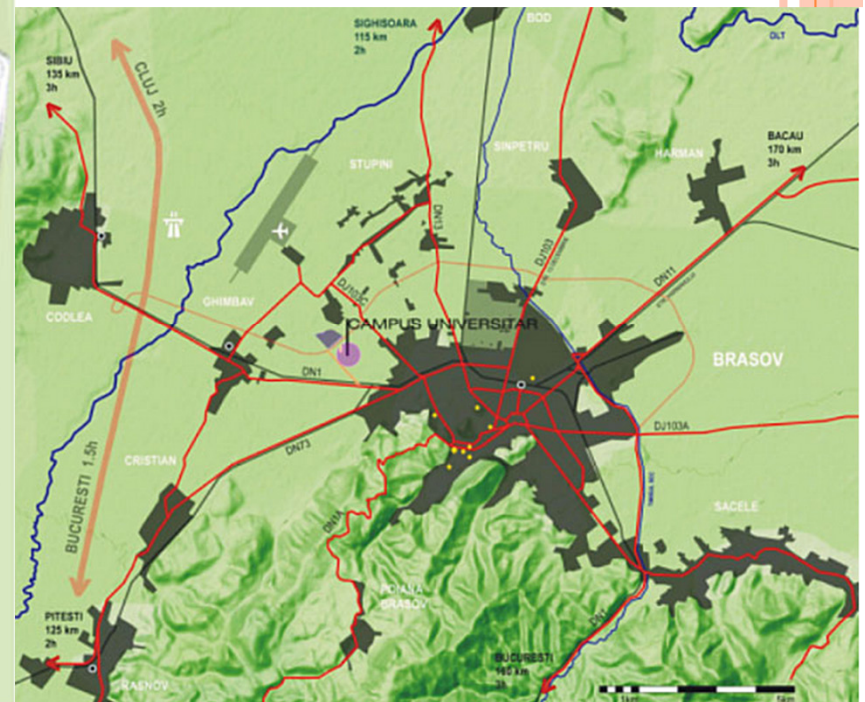
- **18 Faculties**
- **27,000 students**
- **Graduates, Masters and PhD students**
- **More than 800 professors**



INSTITUTE FOR SUSTAINABLE DEVELOPMENT “GENIUS” CAMPUS



March 2012 Inauguration of PRO-DD
Institute
12 Research Departments oriented to
durable development
Full Institute become an example of eco-
friendly buildings using in principal
renewable resources



DOMOTICS (HOME AUTOMATIONS):

- *Science focus on research and improvement of domestic & buildings systems able to offer welfare, comfort, automation of devices & lightings (white goods, HVAC, security, access, safety, protection against fire), entertainment, communication, health & social remote integration and assistance of peoples inside the building, energy management and services offered for home inhabitants all these systems creating for the peace of mind and optimal condition inside the living environment*
- Systems based of microcomputers (microcontrollers) and embedded systems that implement the home automations, including the communication systems. These systems assure the inter-correlation between elements using wired and/or wireless networks, whose characteristics are adapted in the sense of the ubiquitous feature from inside and outside the home.
- The actual trend includes also the participation of buildings facilities at the intelligent supplying and consumption of energy in the grids and also integration of RES and electro-mobility inside distribution networks

WHAT MEANS HOME APPLIANCES?

...a technological science which

- studies all devices in the house or the building, facilitating the work and increasing the comfort of peoples,
- health and remote assistance intelligent devices
- is focused on the integration of all automations within the house,

...and

- creates an ideal environment for the human life → the **DREAM HOUSE !**



WHERE WE MEET THE BUILDING AUTOMATION SYSTEMS?

- In our houses
- In office buildings
- In the public buildings, such as: airports, railways stations, cultural cities – theaters, cinema halls -; sport arenas, etc.
- Industrial buildings
- Green houses



ENERGY AND HIS CHARACTERISTICS

- Energy: Capacity to provide an action

(from the Greek ἐνέργεια - *energeia*, "activity, operation", from ἐνεργός - *energos*, "active, working" [1])

- Electrical energy must be consumed when it is produced (*volatility*), in all other situation appear losses
- *Finite* character of energetic resources and power generation
- The *multidimensional* forms of energy: electrical, mechanical, chemical, thermal, radiant, etc.
- Offer an *Integral image* of movement as reflection of energy

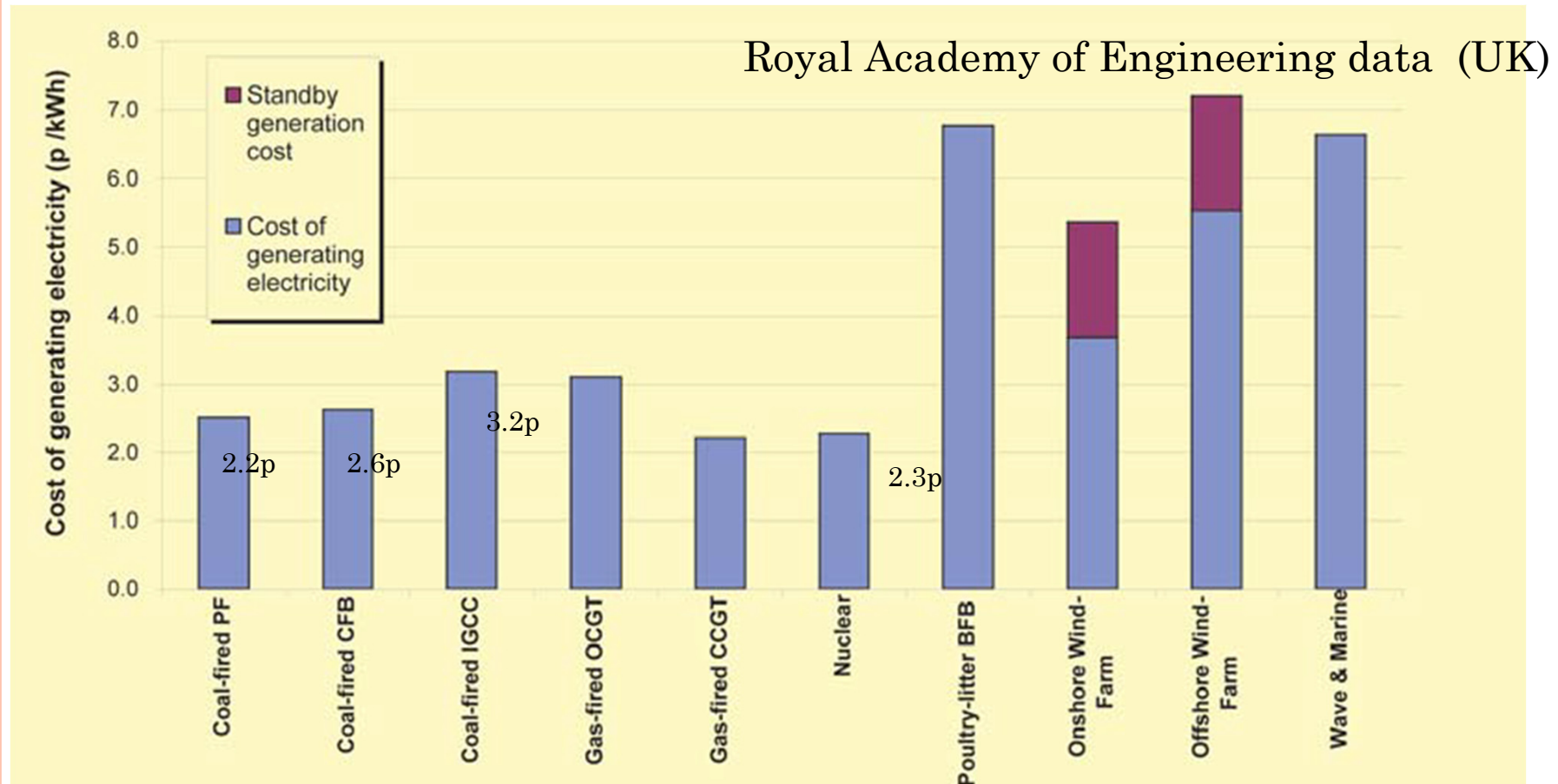


RAW MATERIAL USED AS ENERGY SOURCES

- Conversion of fossil energy in electricity
- *chemical way* - or co-generation (CHP) from:
 - Coal
 - Petrol
 - Natural gas
 - Atomic
- Capture of Sun energy
- *radiant way* - by renewable:
 - Direct solar radiation conversion by PV cells
 - Thermal cells
 - Wind mills and wind farms power
 - Water by hydro-electric power
 - Wave energy
 - Biomass based power plants



PRICE FOR DIFFERENT FORMS OF GENERATION

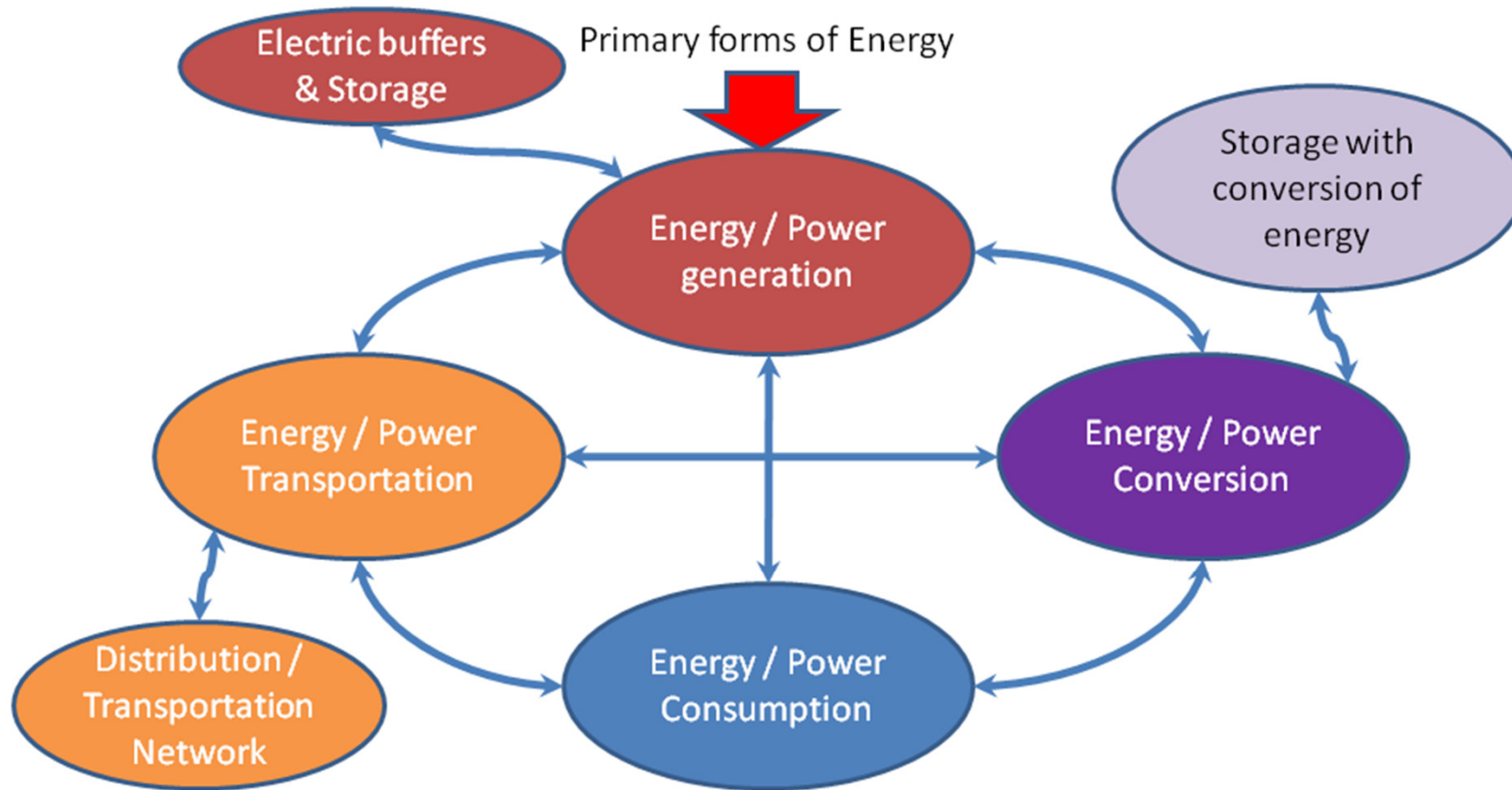


http://www.raeng.org.uk/news/publications/list/reports/Cost_Generation_Commentary.pdf see on April 2012

- Pulverised fuel (PF) steam plant;
- Circulating fluidized-bed combustion (CFBC) plant;
- Integrated gasification combined-cycle (IGCC)

- Open-cycle gas turbine (OCGT) plant;
- Combined-cycle gas turbine (CCGT) plant;

ONTOLOGY OF ENERGETIC PROCESSES



SEVERAL FEATURE OF PRIMARY FORMS OF ENERGY

- The fossil fuels present a high energy density
- Fossil fuels generate “greenhouse” gases
- Technologies are mature

- The “green” technologies are dependent on sun radiation and also local factors: latitude, climate
- Part of technologies are in research phase or “earlier” stages of implementation



STORAGE OF ENERGY

- Rapid release electric storage buffers:
 - Superconducting electromagnetic energy storage
 - Supercapacitors
- Medium and slow release energy storage buffers:
 - Potential mechanical storage (accumulation lakes)
 - Kinetic energy stored by flywheels
 - Air compressed buffers
 - Chemical storage in batteries
 - Hydrogen vector (electrolyses & fuel cells)

➤ **Capacitance (capacity)**
➤ **Speed of feeding/releasing**
➤ **Other characteristics**




EXCHANGE OF ENERGY

- Transfer of electric energy through grids:
 - Transport of energy
 - Distribution of energy
 - Insulated generation & consumption
- Conversion of electrical energy in other forms of energy:
 - Thermal
 - Mechanical
 - Radiant
 - Chemical

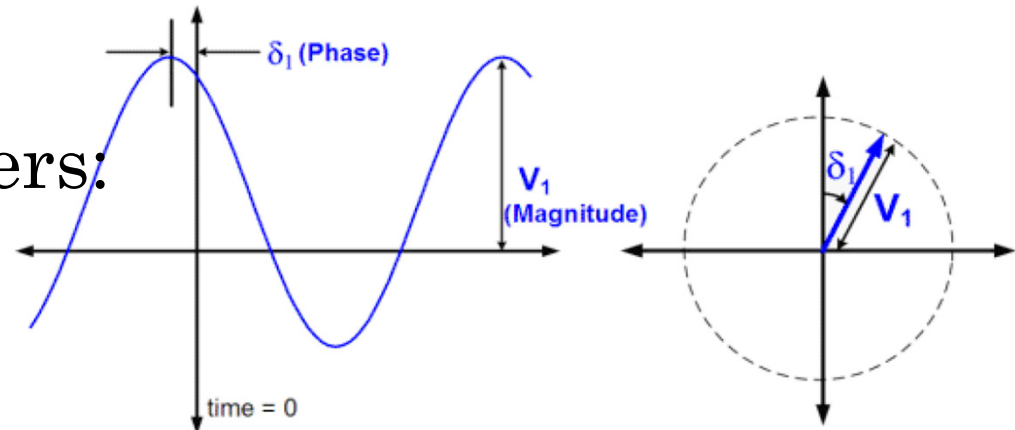


FACETS FROM ONTOLOGICAL POINT OF VIEW RELATED TO THE ENERGETIC PROCESSES

- Energetic capacities & Power flows (*finite*)
 - Information flow (*essential to optimize the efficiency*)
 - Effects of energy (*“usage value”*)
 - Environmental concerns (*“eco-footprints”*)
 - Economical effects (*“smart systems”*)
 - Societal effects (rules, regulations, contracts for providing, consumption and quality of energy supplied)
 - Opportunity of generation, consumption & conversion (generation characteristics, load characteristics, load “demands” - matching phenomena -)
- 

PARAMETERS AND CHARACTERIZATION OF ENERGY PROVIDED

- Type of power flow variation in time:
 - Alternative current:
 - Mono phase
 - Three phase
 - Multi phase
 - Direct current
- Electrical parameters:
 - Voltage
 - Current
 - Power
 - Frequency
 - Phase
- Qualitative parameters:
 - Noise spectrum
 - Availability of power supplies
 - Reliability of providing process



MATCHING PROCESSES IN POWER FLOW TRANSFER

- Types of systems that implement the matching processes:
 - Electrical transformers
 - Voltage control rectifiers
 - Inverters
 - Noise cancellers (quality of power flow variation)
 - Management of energy (time oriented matching processes)
 - Active Filters (Power quality assurance)
- Electronic power commutation devices implement the majority of matching processes
- Types of commutation processes:
 - Forced
 - Natural (or crossing zero / resonant converters)



OTHER ENERGY CHARACTERISTICS

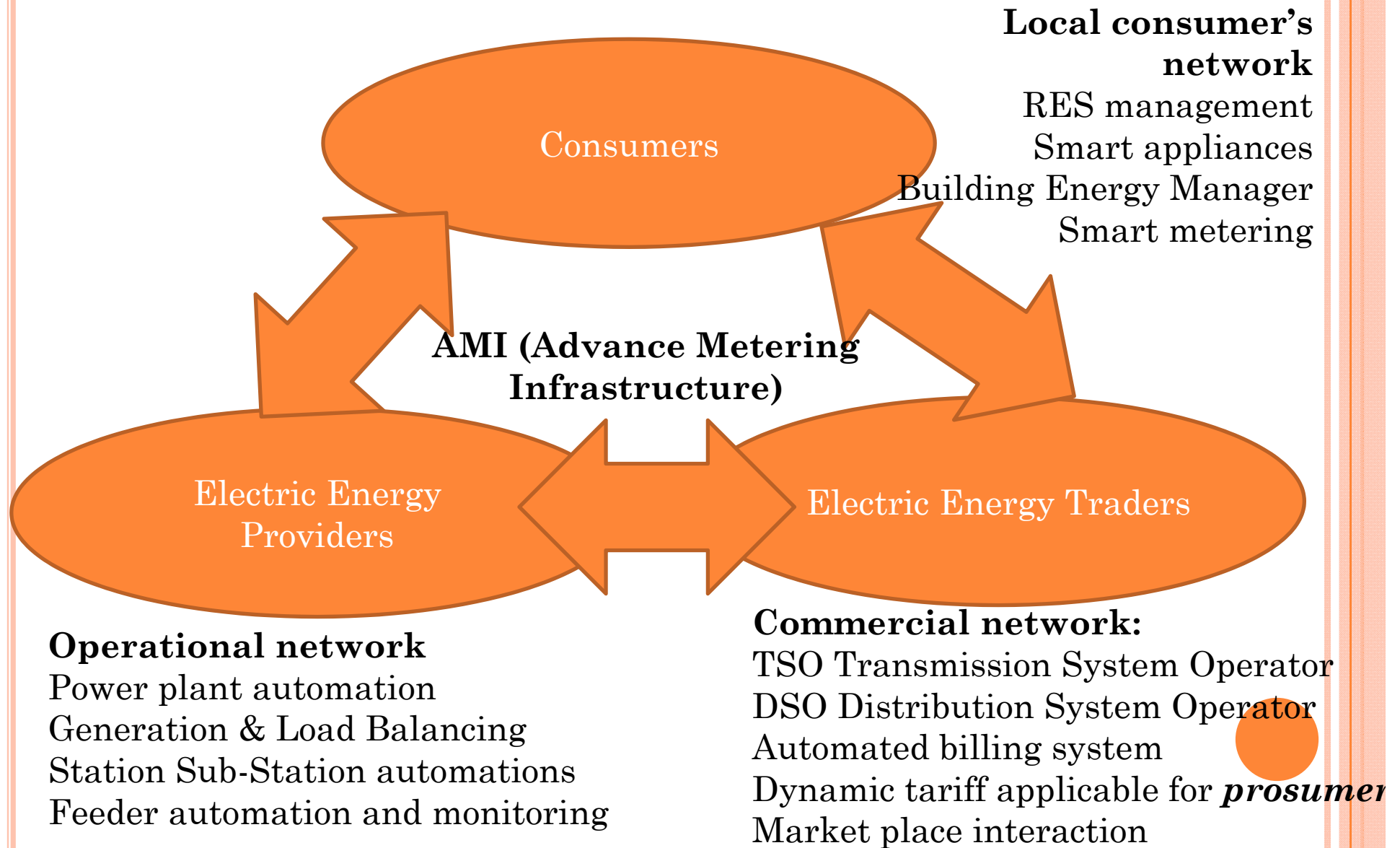
- Granularity of the system (from power and information embedded into the system elements)
- Capacity and reaction speed of the electricity system
- Stability of the system assured:
 - In the past: by over-generation and central control of the power flow
 - In the present and more in the future: by embedded of control at very low level in order to find out the equilibrium at the level of elementary groups (e.g. case of Distributed Generation most remarkable example: Renewable Energy Sources RES) that minimize the power flow circulation and successive conversions

STEPS TOWARD TO MAXIMIZE EFFICIENCY IN GENERATION, TRANSPORT, CONVERSION AND CONSUMPTION OF ELECTRICAL ENERGY

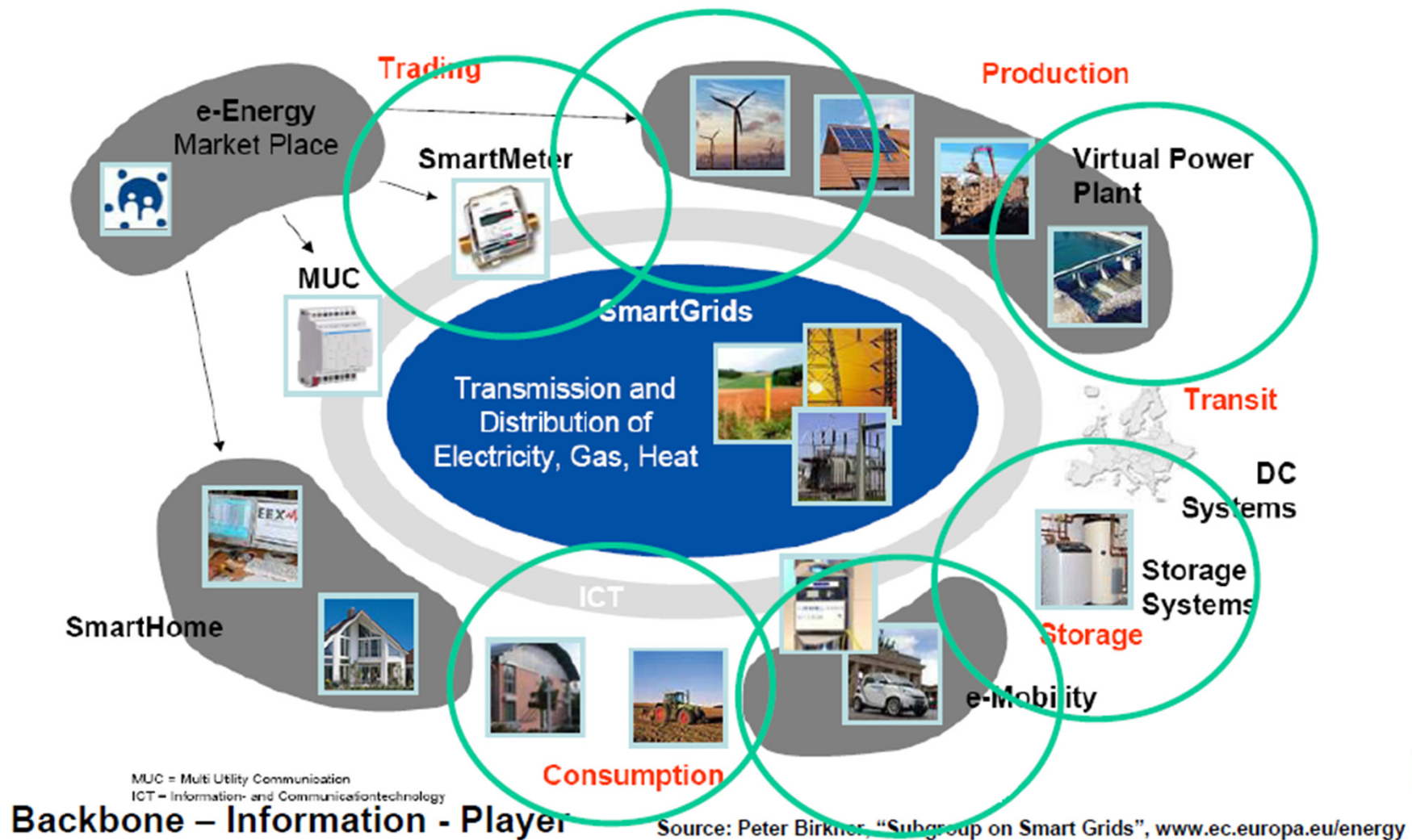
The problem is a COMPROMISE Wisdom in choosing of targets/objectives for optimal

- Uniform definition of the multidimensional problem
- Adoption of the optimal granularity for the system elements
- Choosing of the appropriate model and developing of virtual models to easier the control process that assure the mastering of the system complexity
- Choosing of the right informational system attached at the energetic system able to process, communicate and real time control of the system. The common languages, the appropriate protocols used for communication represents promises to

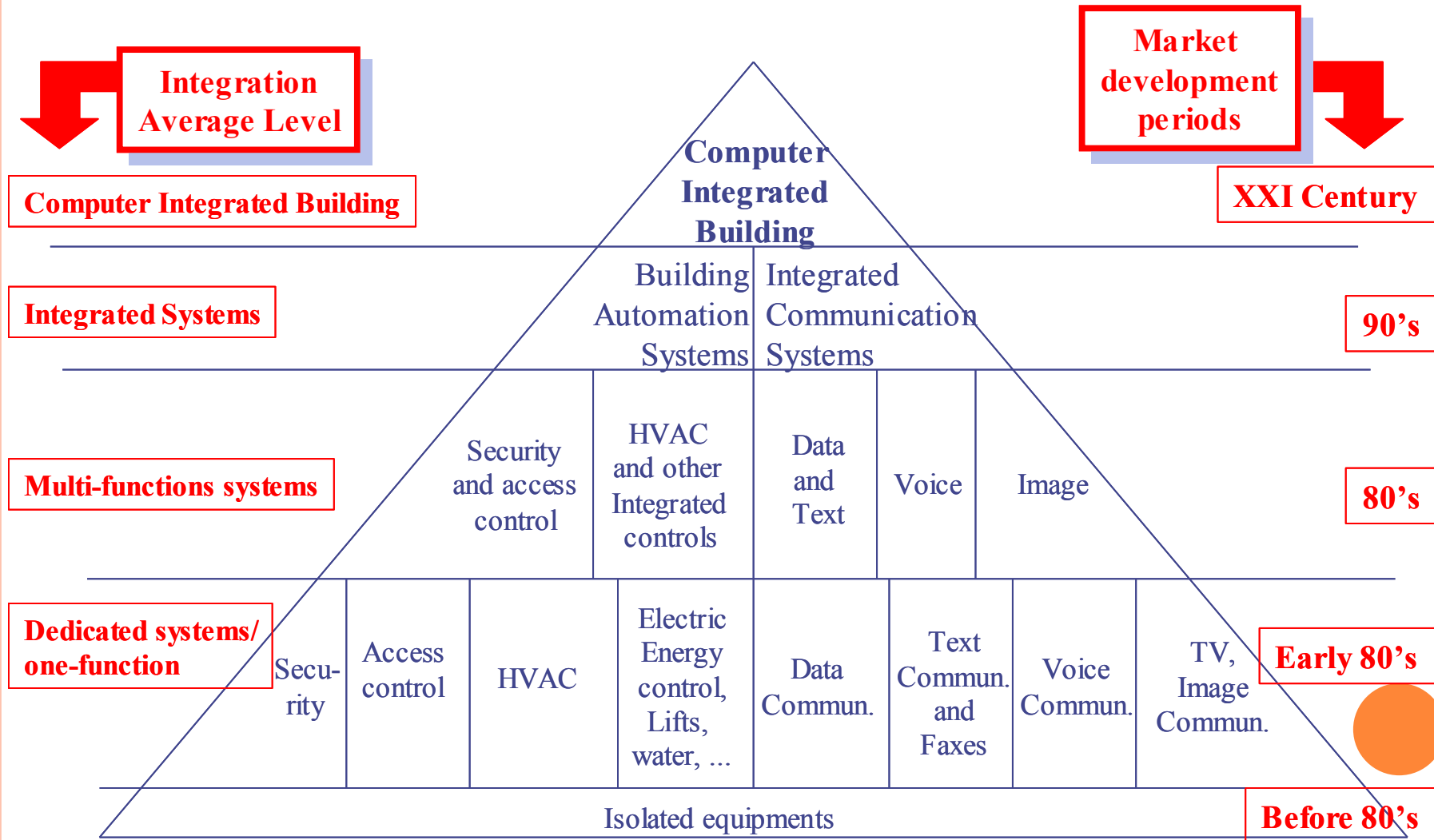
TRINOMIAL MODEL OF SMART GRIDS



SMART GRIDS A VISION ABOUT FUTURE POWER NETWORKS – SMART HOME COMPONENT -



HISTORIC & ROADMAP VIEW ON DOMOTICS



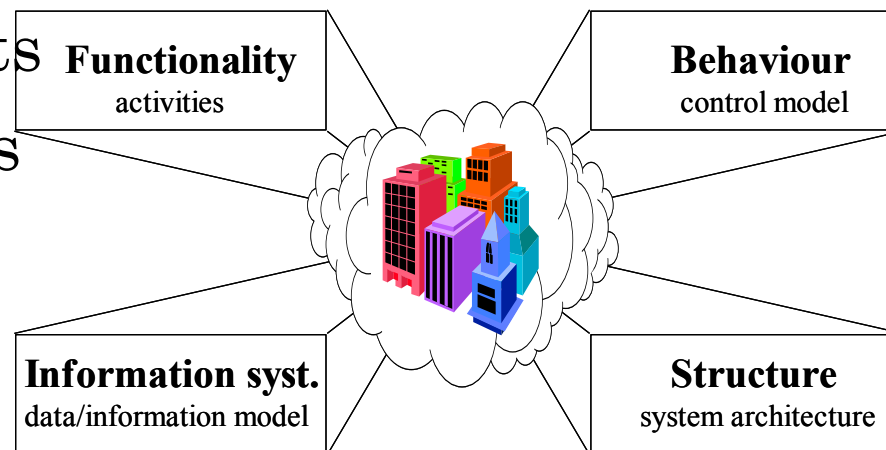
COORDINATES OF THE HOME APPLIANCES

Point of view:

- **STRUCTURAL** that means image of all elements included in house automations with their links
- **FUNCTIONAL** that means the capacity of subsystems to implement useful functions in house.

Nature of elements:

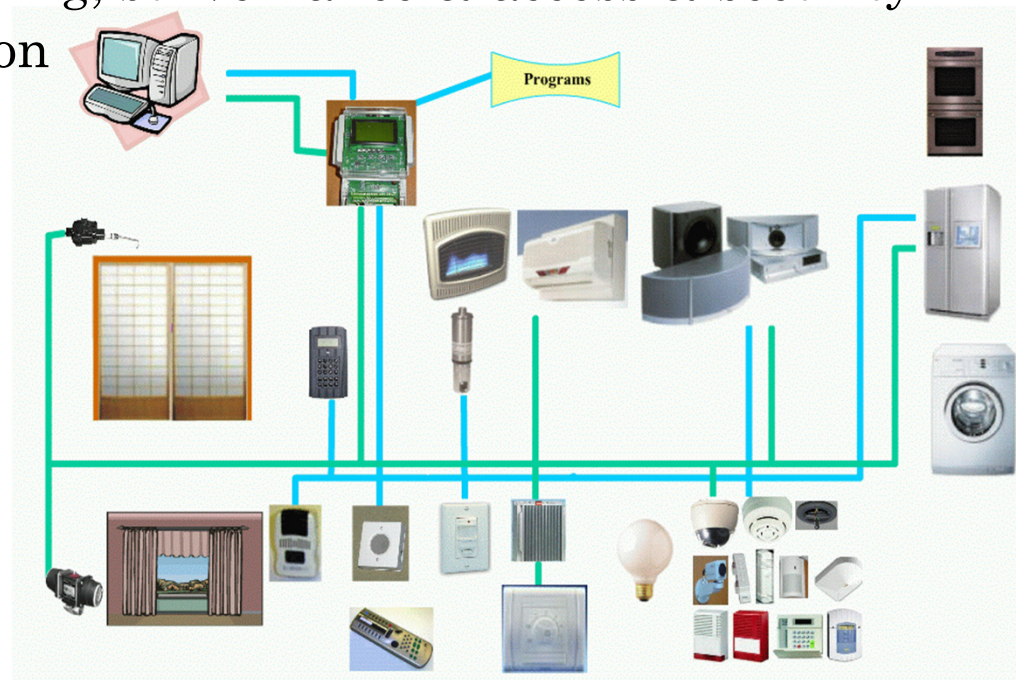
- **HARDWARE** elements
- **SOFTWARE** elements



FACETS OF HOME AUTOMATION SYSTEMS

Specific function control:

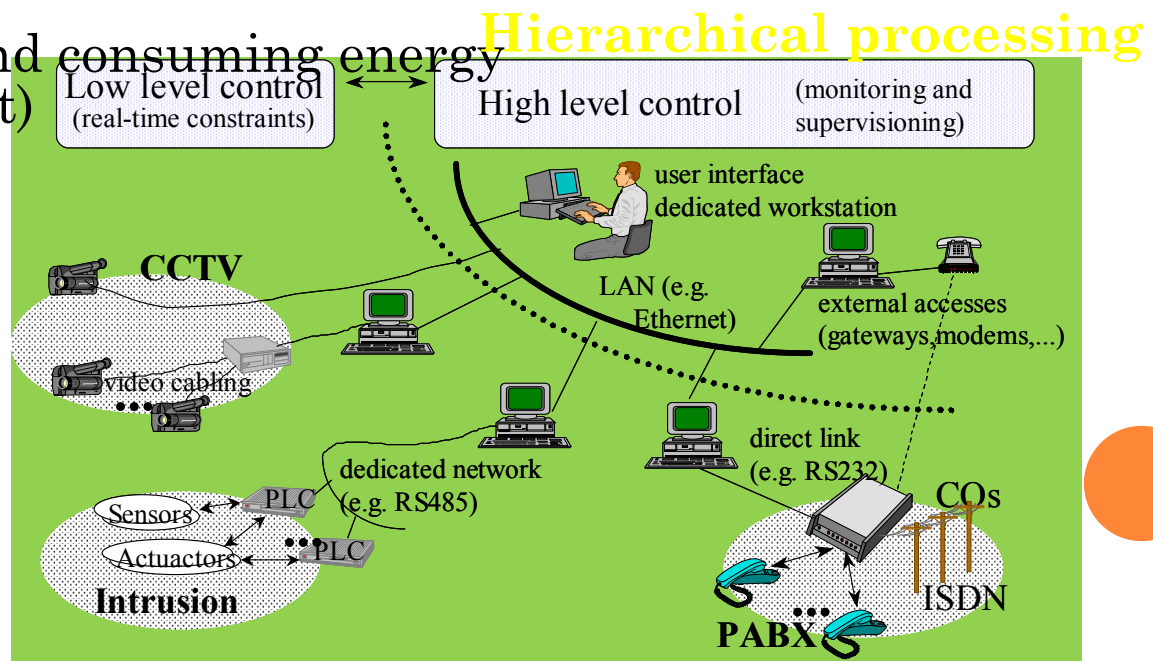
- Temperature (thermal comfort)
- Lighting (level of illumination)
- White goods (electric refrigerators, freezers and their combinations, household washing machines, electric tumble dryers, combined washer-dryers, dishwashers, household lamps, room air conditioners, ovens, vacuum cleaners, etc.)
- Home entertainment
- Management of utilities: gas, water, electrical energy
- Home monitoring, surveillance & access & security
- Communication



MAIN FUNCTIONS IMPLEMENTED BY HOME AUTOMATION SUB-SYSTEMS

Steps lengthwise signal processing

- Acquisition of signals (sensing)
- Processing (data collections)
- Communications
- Actuators (Acting systems)
- Correlation of home automation sub-systems (inter processing)
- Monitoring of principal signals and home security and surveillance
- Producing storing and consuming energy (energy management)



MAIN ELEMENTS OF THE SYSTEM

- **Electric Energy Generators & Storage Elements**
- **Consumers in Buildings, Houses, Institutions**
- **Embedded Systems** integrated with the first two sub-systems
- **Communication Systems** able to assure a predictable and real time control
- **Measuring, Monitoring, and Acting systems** able to monitoring, pattern recognition, pattern matching and acting in accordance with pre-defined, dynamic or intelligent strategies or laws



FEATURES OF THE ACTUAL MOE SYSTEMS

- Ubiquitous
- Able to integrate, process, communicate and react in real time
- Self healing systems
- Intelligent acting:
 - Able to auto-zooming the focus to the principal, essential events that could appear into the system
- Able to monitories, collect, classify, memorize, utilize and dynamically adapt their strategies as “opportunity” function
- High availability, reliability and resilience

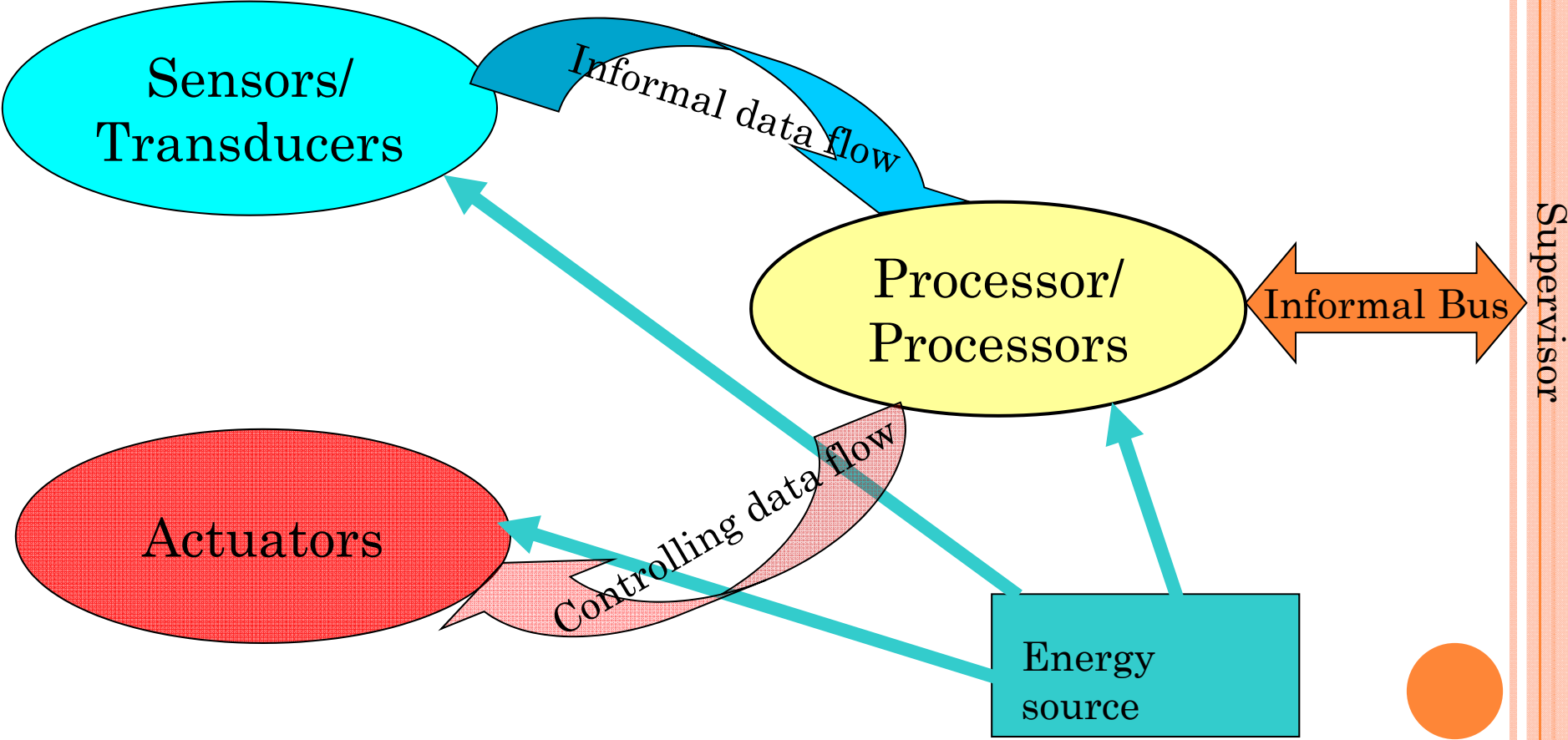


WHAT MEANS A NEW APPROACH IN THE ENERGY MANAGEMENT ?

- Will generate a overall, multi-layer, and comprehensive image about the efficient management of energy resources using scalable, flexible hardware and software instruments
- Using the super-capacitor, like electrical energy buffers at the level of building, we will fill a gap between the existing solutions able to assure the storage of electrical energy specially under impulse form
- For the RES sources existing into the buildings we will assure the smoothing of load curve and the filtration of sag and short deeps
- Acting intelligently based on self experience or network experiences
- Bidirectional and very fast, reliable, redundant and resilient communication systems

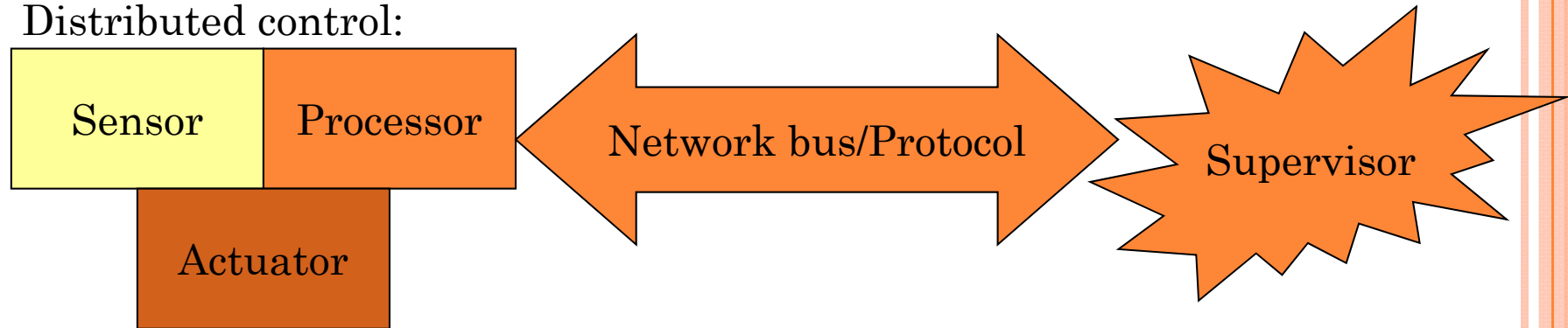


GENERAL SCHEME OF A LOCAL CONTROLLER

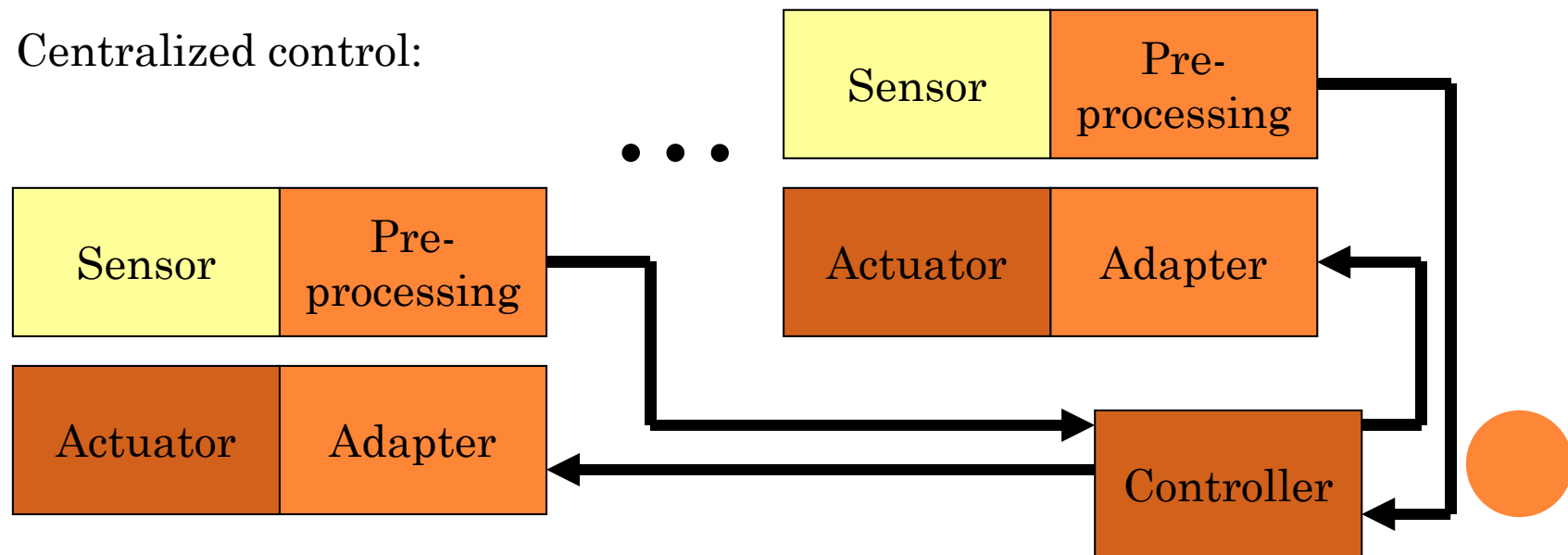


POSSIBLE IMPLEMENTATION SOLUTIONS (HARDWARE)

Distributed control:



Centralized control:

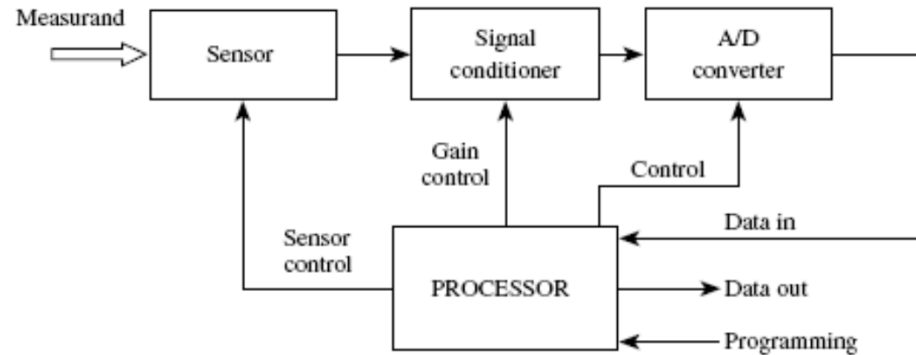


SMART HOUSE MEANS AUTOMATION AND COMMUNICATION

- The processing capacity could be very different: from simple process of temperature, humidity, light flow, position in space till image processing virtual and augmented reality used as advanced human machine interfaces or even in case of machine to machine communication –see inter correlation between with goods in house or between entertainment devices –
- The communication systems are very varied from simple wired buses –majorities series – till wireless communication systems (Bluetooth, Zigbee, RouBee, Wi-Fi, GSM, UMTS, RTE or Wi-Max)

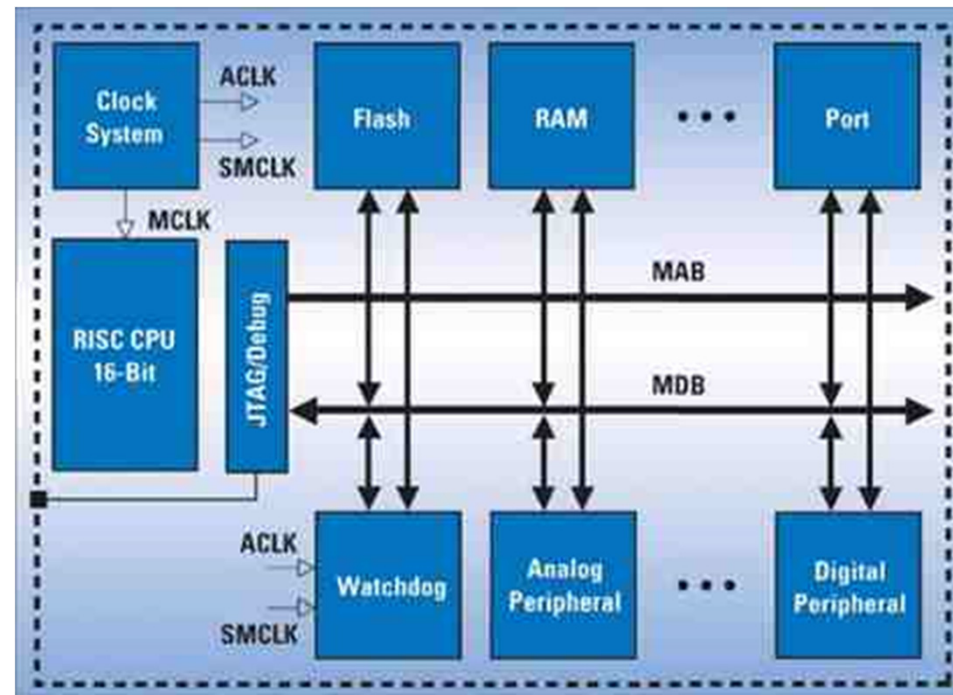


SMART SENSOR & ACTUATORS IN A SINGLE CHIP USING MSP430 -MIXED SIGNAL PROCESSOR-



Advantages:

- ❑ Include all the functional blocks on the same chip
- 16th bits RISC architecture
- ❑ Very low consumption
- ❑ A large number of interfaces: USART, SPI, I2C
- ❑ Flash memory until 62Kbyte
- ❑ Includes A/D and D/A converters



MICROCONTROLLERS –AVR8/AVR32 OR ATXMEGA FAMILIES

- Programmed microcontroller having a Harvard architecture
- Clock facilities including 6 clock sources, watch dog timer (WDT), and reset (cold&warm)
- Includes general purpose input /output ports (GPIO)
- Includes analog to digital convertor (ADC) and two analog comparators
- Includes peripheral elements USART, SPI,TWI and JTAG interfaces
- Memory: flash for programs (organized on 16 bits) & EEPROM, SRAM (organized on 8 bits)
- Precise internal oscillator & External oscillator
- Interrupt controller with vectorized service routines



PROGRAMMABLE SYSTEM ON CHIP (PSoC) CYPRESS PSoC05

- Allow both a hardware programming and configuration and program running in order to achieve the desired functionality

Main functions provided and flexible programmed:

System resources (clocks, Real Time Clock (RTC) and reset facilities, with or without PLL)

Power management system with programmed variation of supplied voltage from 1.8 till 5V

Analog system that allow ADC and DAC function (12 bits resolution)

Universal Digital Array Blocks (24) allowing mapping and routing of all digital function of external processor's pins

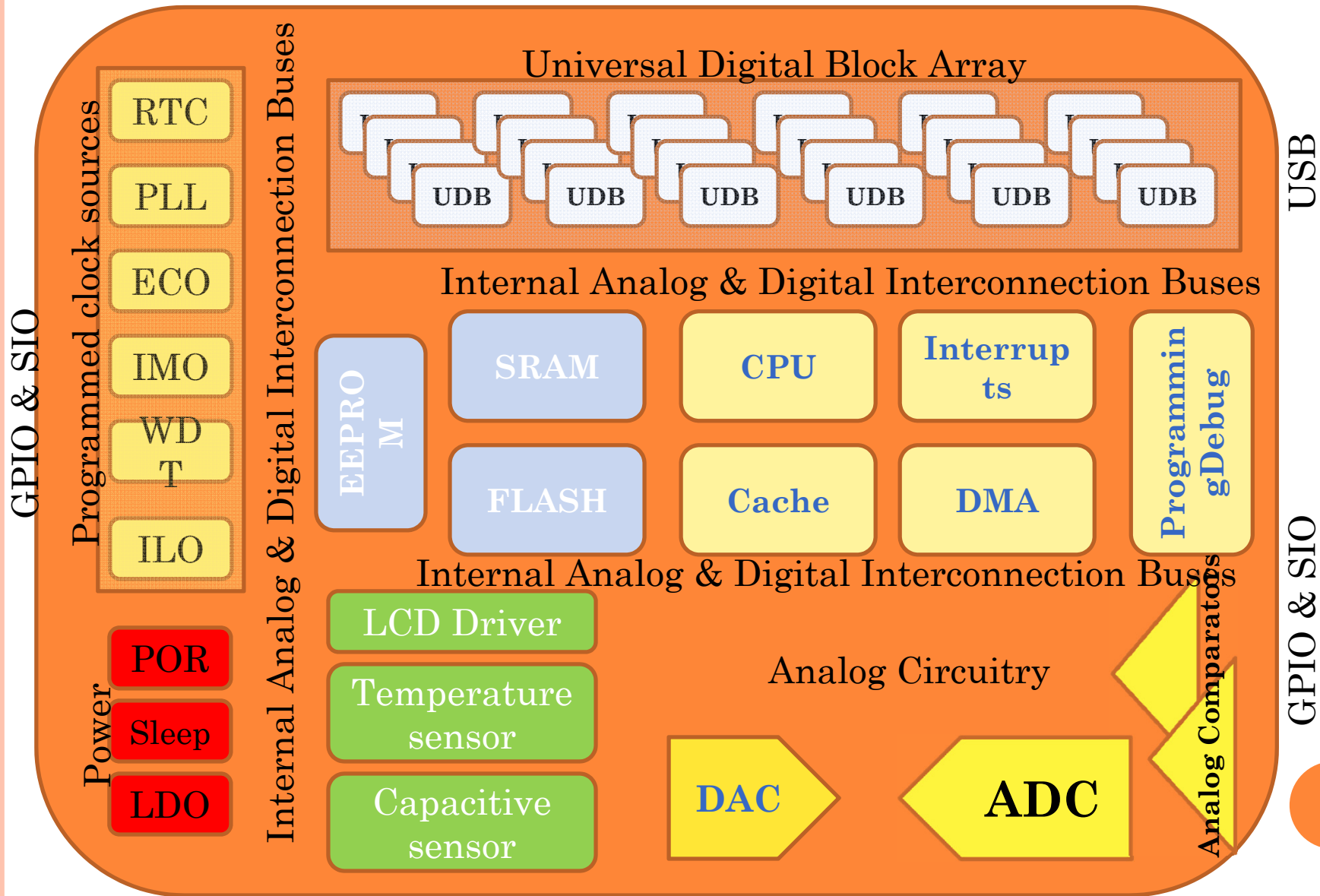
Central processing unit (MCS51 -8 bits or ARM 3 Cortex -32 bits)

Memory subsystem (Flash, SRAM and EEPROM)

Programming and debugging interfaces



INTERNAL STRUCTURE OF PSoC

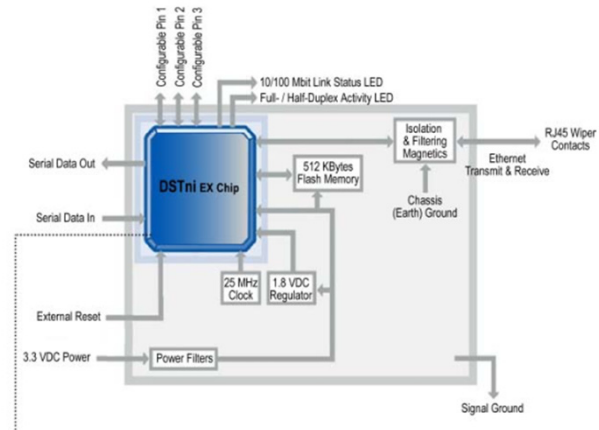


COMMUNICATION ELEMENTS INCLUDED INTO EMBEDDED DEVICES

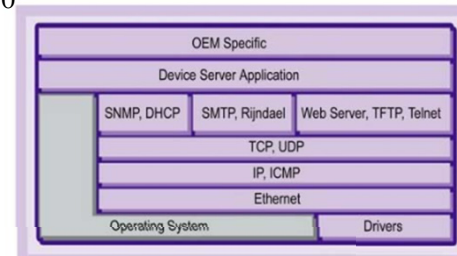
Wired communication devices



XPort Data Sheet 910-815F May 2010

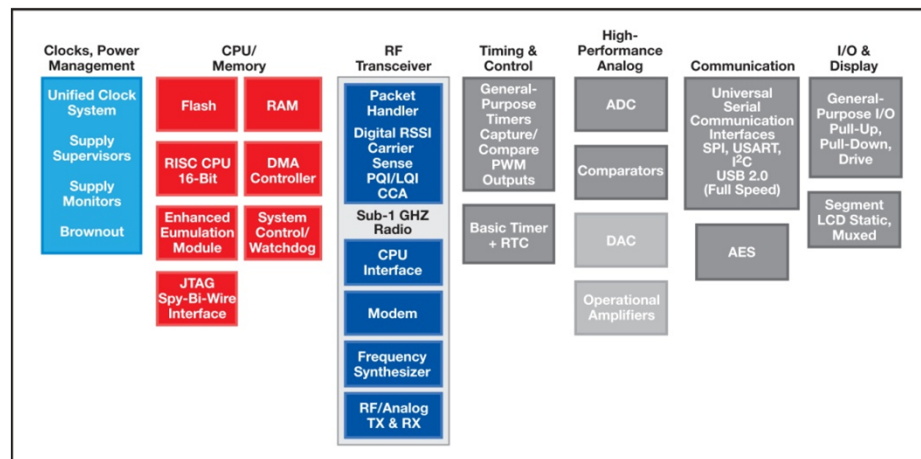


Wireless communication devices



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Lantronix, XPort, with its patented technology (US Patents 6,881,096 & 4,972,470),



WIRED CONNECTIONS

- X-Port LANTRONIX offer the following features:
 - Processor: Lantronix DSTni-EX 186 CPU, 256 KB zero wait state SRAM 512 KB Flash, 16 KB Boot ROM
 - Maximum speed: 921600bps
 - Network interface: RJ45 Ethernet 10BASE-T or 100BASE-TX
 - Protocols: ARP, UDP/IP, TCP/IP, Telnet, ICMP, SNMP, DHCP, BOOTP, TFTP, Auto IP, and HTTP
 - Management using internal Web server, SNMP, Serial UART, telnet.
 - Weight 9.6 grams
 - Form factor and case RJ45
 - Voltage 3,3V / current max. 60mA



WIRELESS COMMUNICATION DEVICES 1/2

- Bluetooth device LMX9838, features:
- Completely compatible with 2.0 Bluetooth standard protocol
- Protocols accepted; L2CAP, RFCOMM,SDP
- Profiles: GAP(Generic Application Profile), SDAP (Service Discovery Application Profile), SPP(Serial Port Profile)
- Maximum baud rate: 921600bps
- Range less than 100m on open air
- Voltage: 3-4V, Current: 65mA



WIRELESS COMMUNICATION DEVICES 2/2

- ZigBee device CC2420, features:
- Completely compatible with IEEE 802.15.4 standard protocol
- MAC support
- Programmable output power and sensitivity at reception
- Support for: RSSI / LQI
- Allow MAC encryption AES-128
- Maximum baud rate: 250000bps
- Range less than 100m on open air
- Voltage: 2.1-3.6V, Current: 18.8 /17.4 mA (Rx/Tx data)



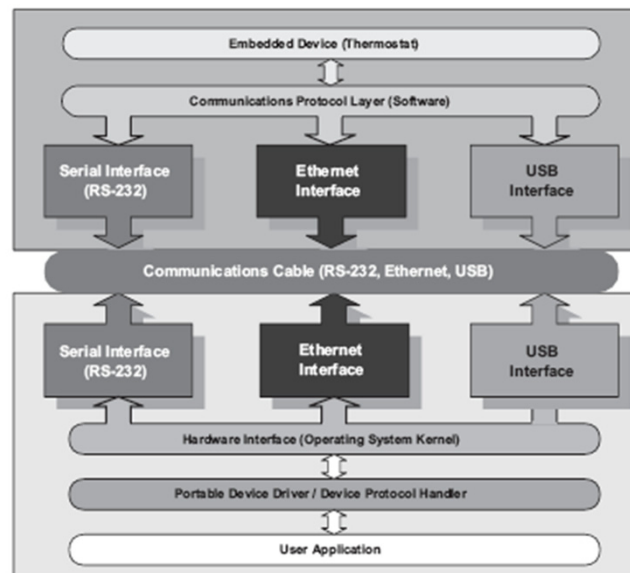
LOCAL PROCESSING SYSTEMS: PROBLEMS TO SOLVE

➤ Structure & Functionality of sensors:

- Sensors;
- Processors;
- Energy sources

➤ Communication networks: topologies & protocols:

- Mesh (mesh based)
- Star (node based)
- Bus



To measure:

- Temperature
- Pressure
- Presence, movement
- Humidity
- Air composition
- Light
- Electromagnetic fields

To process:

- One-dimensional signals
- Images (bi-dimensional)
- Complex signals (correlated)

To supply:

- Locally generated
- Mixed generated
- Central generated and transmitted



TYPE OF SYSTEM REACTIVITY

❑ *Event driven system*

❑ *Programmed actions*

Event: a marked stage of the system that request an specific action

Interrupt: Change the context of program execution, Stop the current program execution, save the status of CPU, recognize the interrupt source, jump to

Interrupt service routine: A sub-routine that describe the specific action triggered by an event

Features of interrupt system:

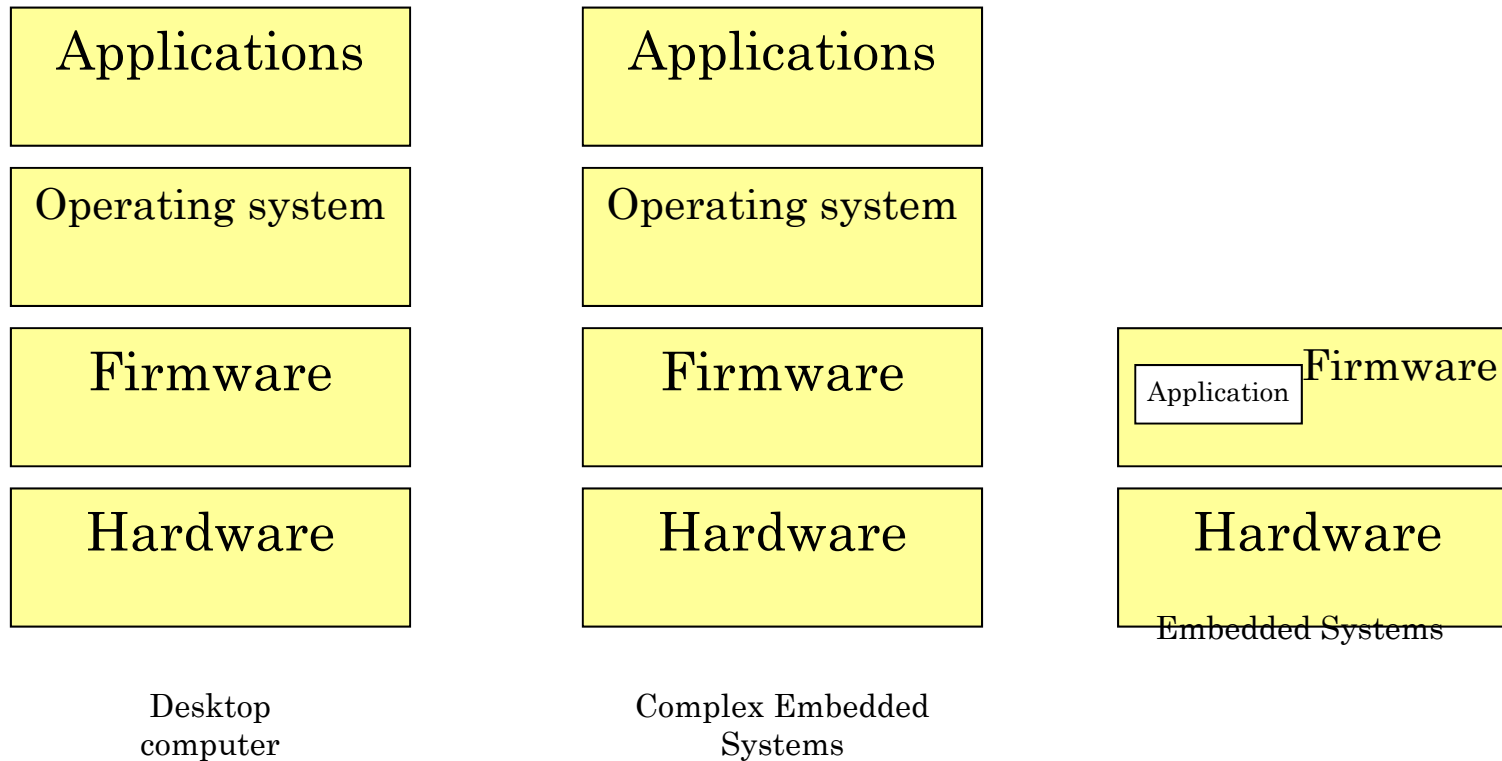
❑ fast response,

❑ specific and

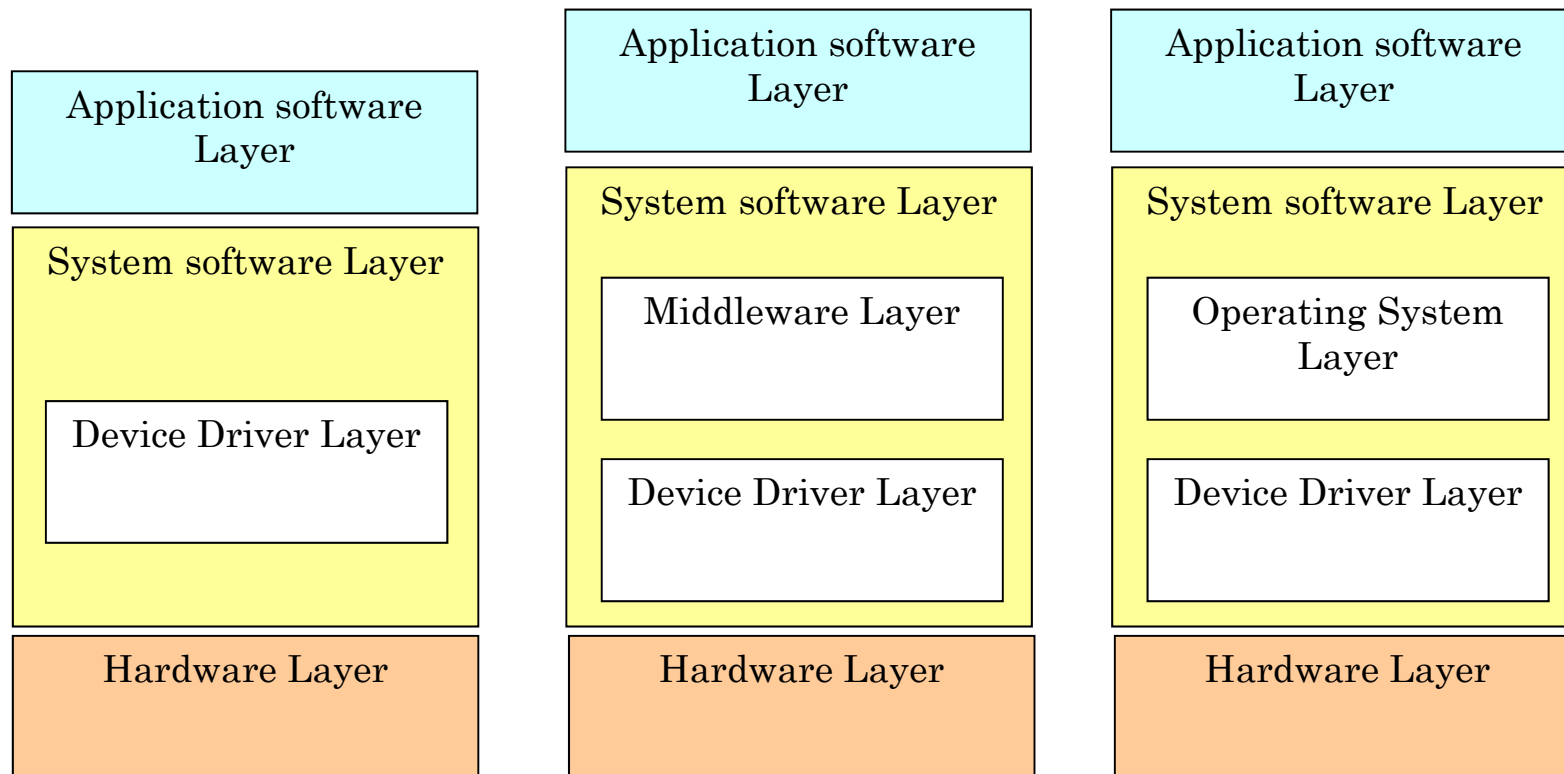
❑ able to prioritizes the service of events



SOFTWARE, FIRMWARE, MIDDLEWARE



TYPE OF SOFTWARE SOLUTIONS



STEPS TOWARD SOFTWARE IMPLEMENTATION OF THE EMBEDDED SYSTEMS

- ❑ Analyzing of process or system that will be implemented
 - ❖ Hardware design
 - ❖ Software design
 - ✓ Developing the corresponding of flow diagrams
 - ✓ Editing the source program (assembler, C, Pascal, etc)
 - ✓ Compiling
 - ✓ Linking
 - ✓ Converting in Intel HEX format to be transfer to the system
 - ✓ Transfer to target system
- ❑ Testing
- ❑ Validating



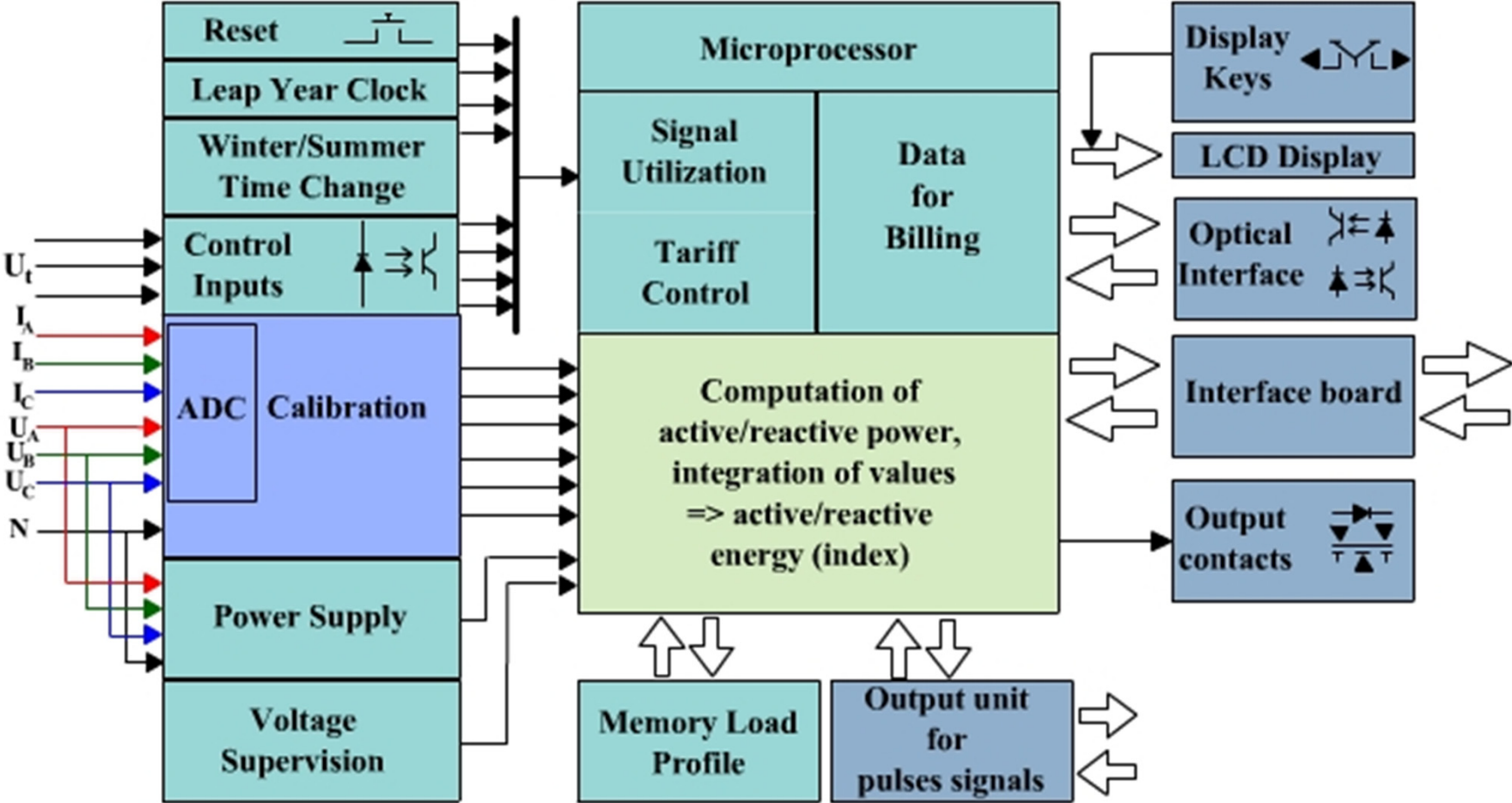
EXAMPLES OF IDE (INTEGRATED DEVELOPMENT ENVIRONMENTS) SEVERAL EXAMPLES

- Atmel AVR families AVRstudio 6.0 (last version)
- MPLAB PIC families
- ICCAVR

The screenshot displays the AVR Studio 6.0 IDE interface. The main window shows the source code for `C:\WORK\SMART2\SMART3.c`, which includes comments for baud rate and parity settings, and defines two interrupt handlers: `uart0_rx_isr` and `uart0_tx_isr`. The `Processor` window on the left shows the current state of the AVR processor, including the Program Counter at `0x0000A3` and a frequency of `4.0000 MHz`. The `Watch` window is empty, and the `Memory` window shows the program memory starting at address `0x000000`. The `I/O View` window on the right displays the I/O peripheral registers, with `PORTC` selected, showing its data register, direction register, and input pins. The status bar at the bottom indicates the target is `ATmega128` in `AVR Simulator` mode, currently `Auto Stopped` at `Ln 95, Col 4`.

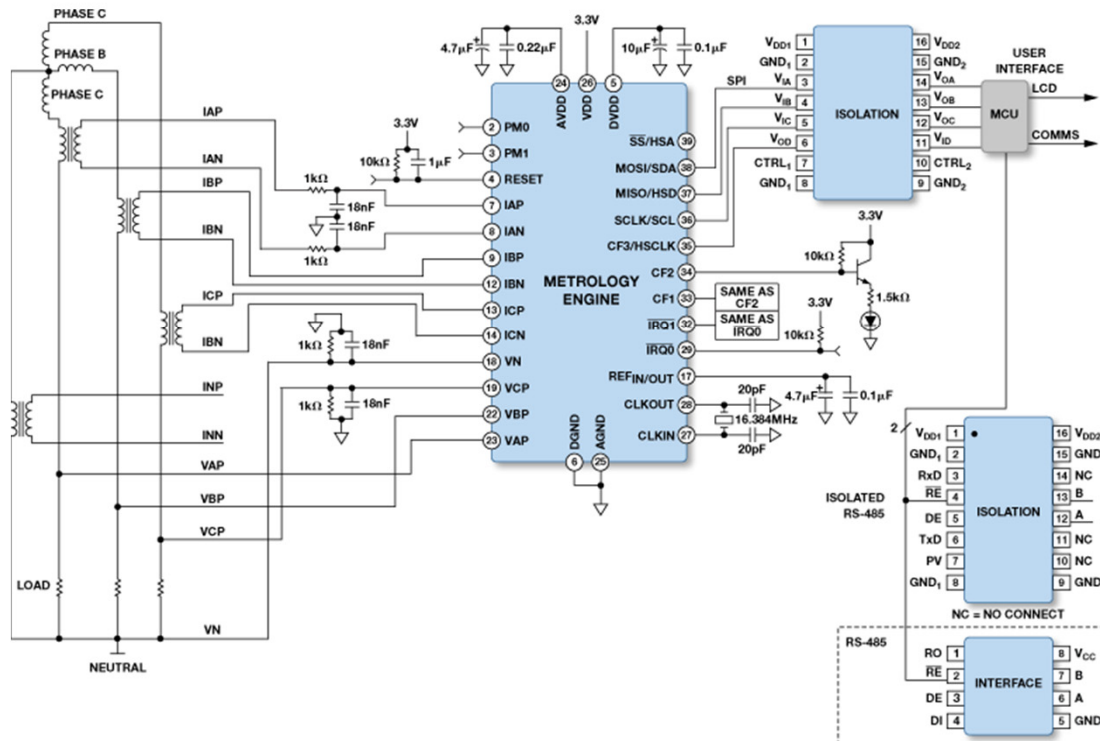
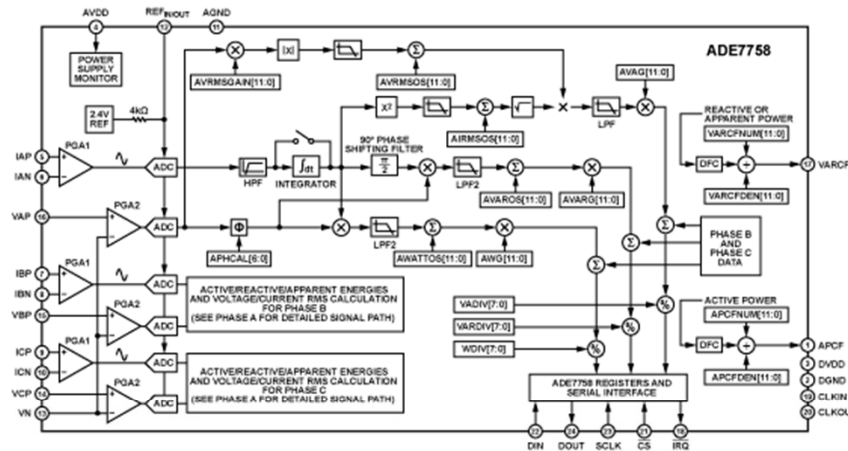


ELECTRIC ENERGY COUNTER



IC METERS

- ❑ Sensors => Precisions of whole system
- ❑ Metering involve CALIBRATION of measurements
- ❑ Communication module could be changed
- ❑ Seals are mandatory
- ❑ Authentication is mandatory



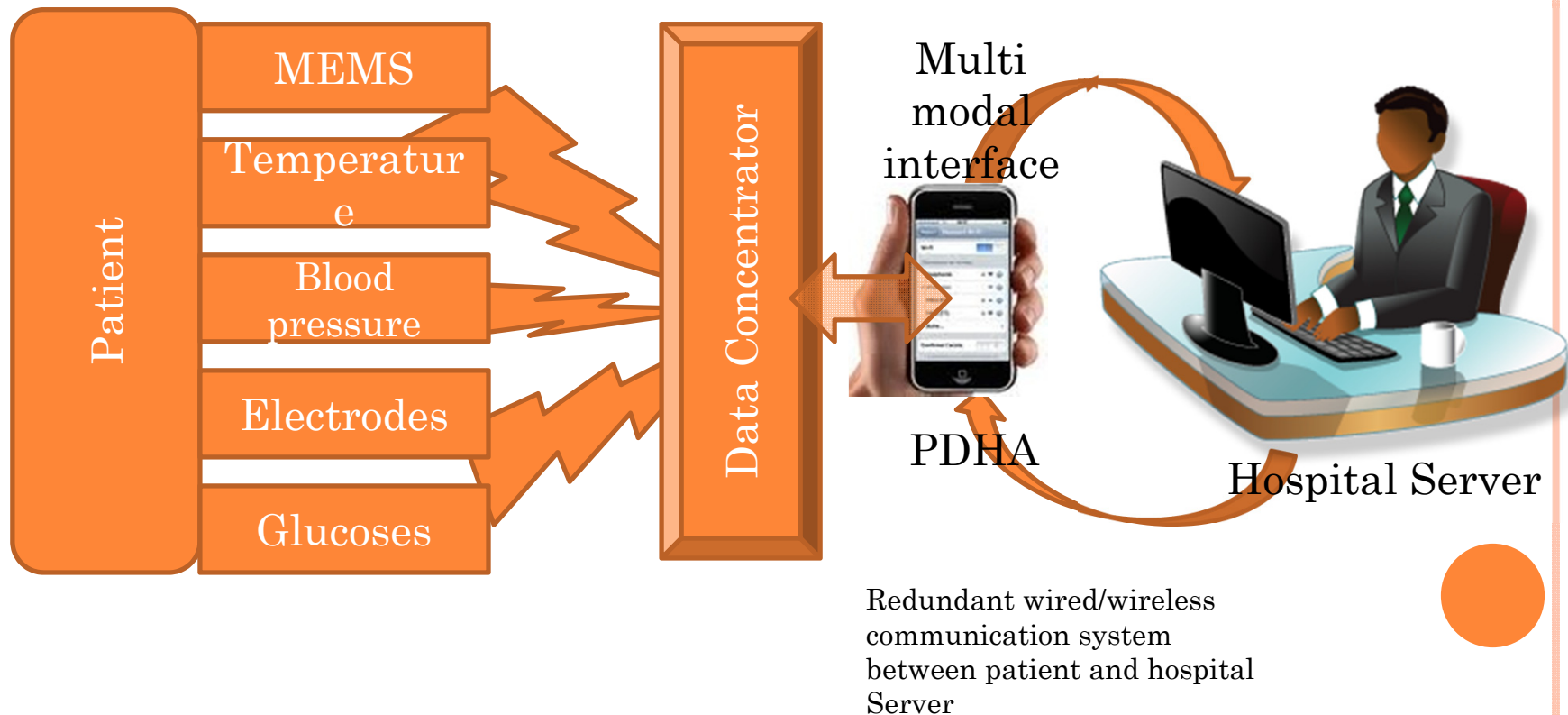
SERVICES RELATED ENERGY CONSUMPTION AND PROVIDED

- Production of electric energy based on wind, hydro or solar
- System services based on storage devices and in the future, electric vehicles
- Management of energy in order to improve the energy efficiency and optimize the functioning costs
- Services related the on-line, real-time peoples information
- Services related the assistance of buildings inhabitants especially elderly and peoples with disabilities
- Services related entertainment and services on demand

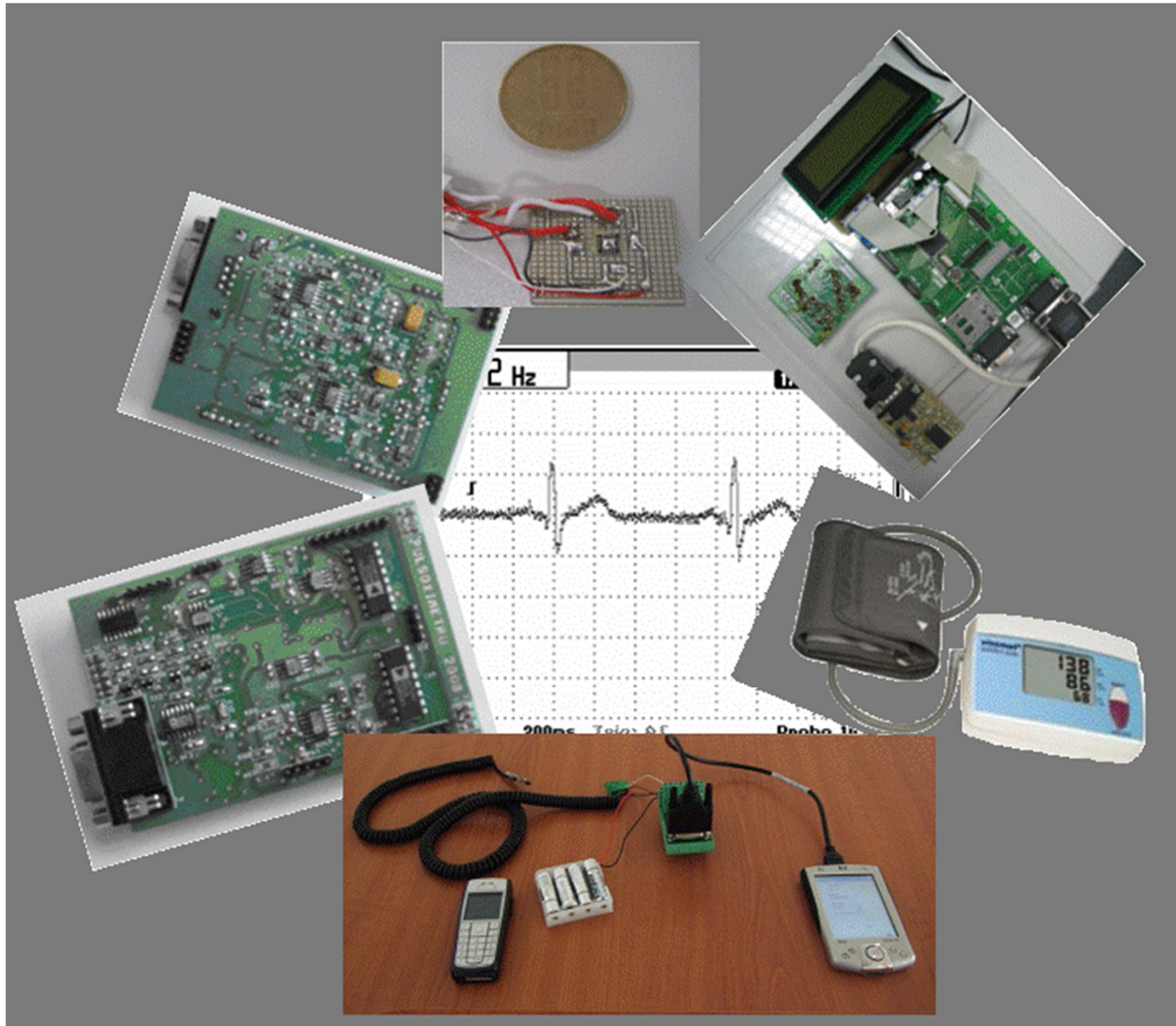


ASSISTIVE TECHNOLOGIES

- Monitoring of vital signs: temperature, pulse, blood pressure, glucoses in the blood , ECG, acceleration of the body
- Remote assistance of elderly peoples



ASSISTIVE TECHNOLOGIES



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Q&A ?

**Thanks for your
attention!**

