Intelligent System Development

Pinit Kumhom

vLSI Design for embedded Systems with intelligence (vDeSi) Lab

Department of Electronic and Telecommunication Engineering

Faculty of Engineering

King Mongkut's University of Technology Thonburi

October 9, 2017

vDeSi
embedding the intelligence

Outline

vDeSi
embedding the intelligence

An intelligent system is an electronic system that is *embedded* to something for performing *specific tasks* with some level of *intelligence*

Let's think about these following systems

- An air conditioner...
- A car...
- A house...
- A phone...
- A watch...
- A rice cooker...

vDeSi
embedding the intelligence

Intelligence on a “field” or a “topic” is an ability to analyze and differentiate things on the field or the topic...

- Intelligence on air conditioning...
- Intelligence on driving a car...
- Intelligence on lighting a house...
- Intelligence on making a phose call...
- Intelligence on health...
- Intelligence on cooking rice...

vDeSi
embedding the intelligence

Doing things with intelligence lead to *high efficiency*, which in turn benefits all parties...

- *Efficiency* is measured in 3 aspects: *energy*, *space*, and *time*
- *High effiency* in doing something implies doing its with less *waste* energy, space, and time.

vDeSi
embedding the intelligence

Intelligence enhances a *product's performance*...

features
specification

- A self-driving car..
- A cleaner that knows where and when to clean...
- A house that knows when to turn on and off elctricity..
- An air conditioner that know where people sit in the room and their temperature preferences...
- etc.

vDeSi
embedding the intelligence

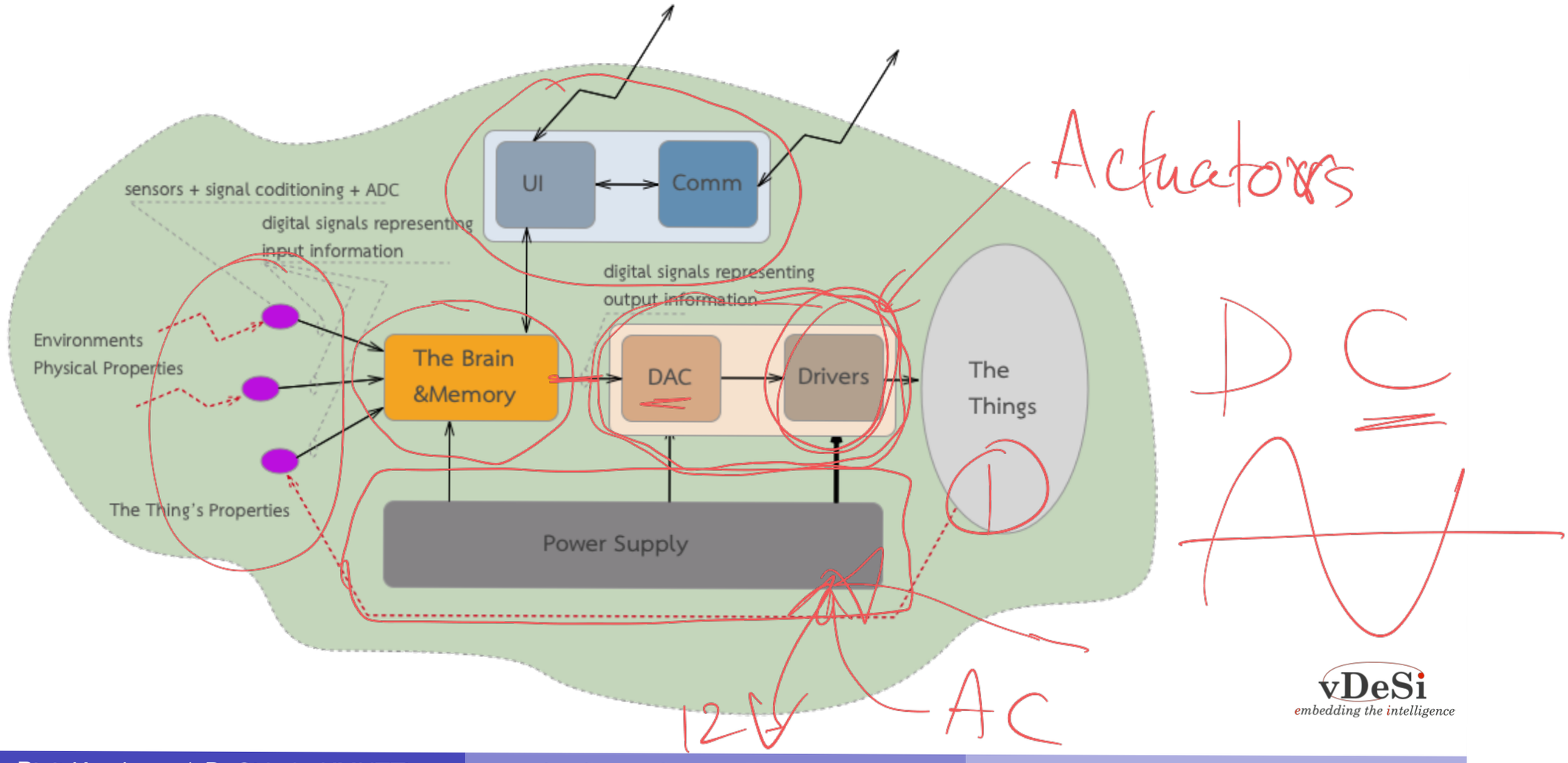
All parties benefits...

- *Makers* $\Rightarrow$ *less cost*
- *Users* $\Rightarrow$ *reasonable price*
- *Stake holders* $\Rightarrow$ *sustainable profits*
- *Others* $\Rightarrow$ *better society and environment*

Outline

vDeSi
embedding the intelligence

An extended intelligent sytem may be decomposed into (1) the things that peroforming the tasks, (2) the signal sensing unit including ADC, (3) the actuator and driver unit including DAC, (4) communication and user interface unit, and (5) the brain...



vDeSi
embedding the intelligence

Outline

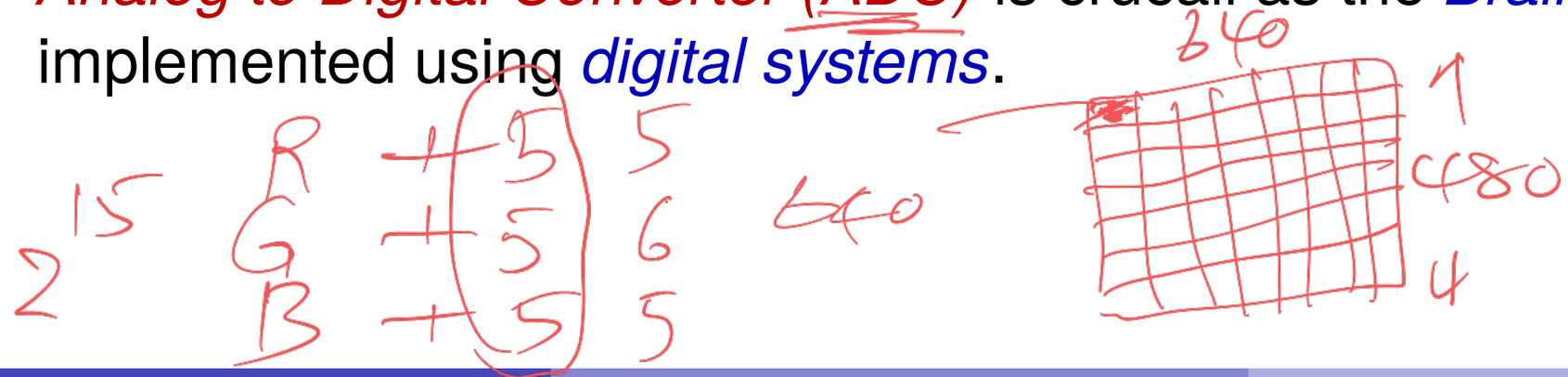
vDeSi
embedding the intelligence

The *signal sensoring unit* job is to convert physical properties of the environment and/or the things' properties to *digital signals*...

- *Microphones* sense *sound* information
- *Cameras* senses *vision* (i.e. images/videos) information
- *Thermal sensors* detect *heat* information; i.e temperature
- *Accelerometers* detect *accelarations* of a moving "thing"
- *Biosensors* detect *cell's properties*
- etc.

Notes:

- Usually a sensor converts physical properties to *analog signal*
- *Analog to Digital Converter (ADC)* is crucail as the *Brain* is usually implemented using *digital systems*.



vDeSi
embedding the intelligence

The *challenges* involving the sensoring unit for an intelligent system is to choose the *"right"* ones...

Key issues about sensors

- They are based on *nature's principles*; i.e. the major science's fields of*physics*, *chemistry*, *biology*.
- *Exercises:* Identify the nature's principles used in the following sensors:
  - *Cameras:*
  - *Microphones:*
  - *Accelerators:*
  - *GPS:*
  - *Heart rate sensor:*

information
experience
process

- They are relied on *technologies* for engineering them

vDeSi
embedding the intelligence

Outline

vDeSi
embedding the intelligence

The *actuators* are devices that convert the *"brain's commands"* to *"actual works"*. It is what make the *things' capabilities*...

Key facts about sensors

- Similar to the sensors, they are based on *nature's principles*; i.e. the major science's fields of*physics*, *chemistry*, *biology*.
- Some sensors/actuators can work as both..
- *Exercises:* Identify the nature's principles used in the following actuators:
  - *Motors:*
  - *Heaters:*
  - *MEMS:*
  - *Think of something*..
- Similar to the sensors, they are relied on *technologies* for engineering them

vDeSi
embedding the intelligence

Outline

vDeSi
embedding the intelligence

intelligent systems no matter how smart they are are designed to *“serve”* humans...

- *A phone* originallly is to make telephone calls, but now ...
- *An air conditioner* ...
- *A car* ...
- *Think of something* that serve people in the future society..

vDeSi
embedding the intelligence

User interface frequently is part of the intelligences...

- *Voice interface*...
- *Gesture interface*...
- *Eye-gaze interface*...
- *Thinks of some interesting interface*

vDeSi
embedding the intelligence

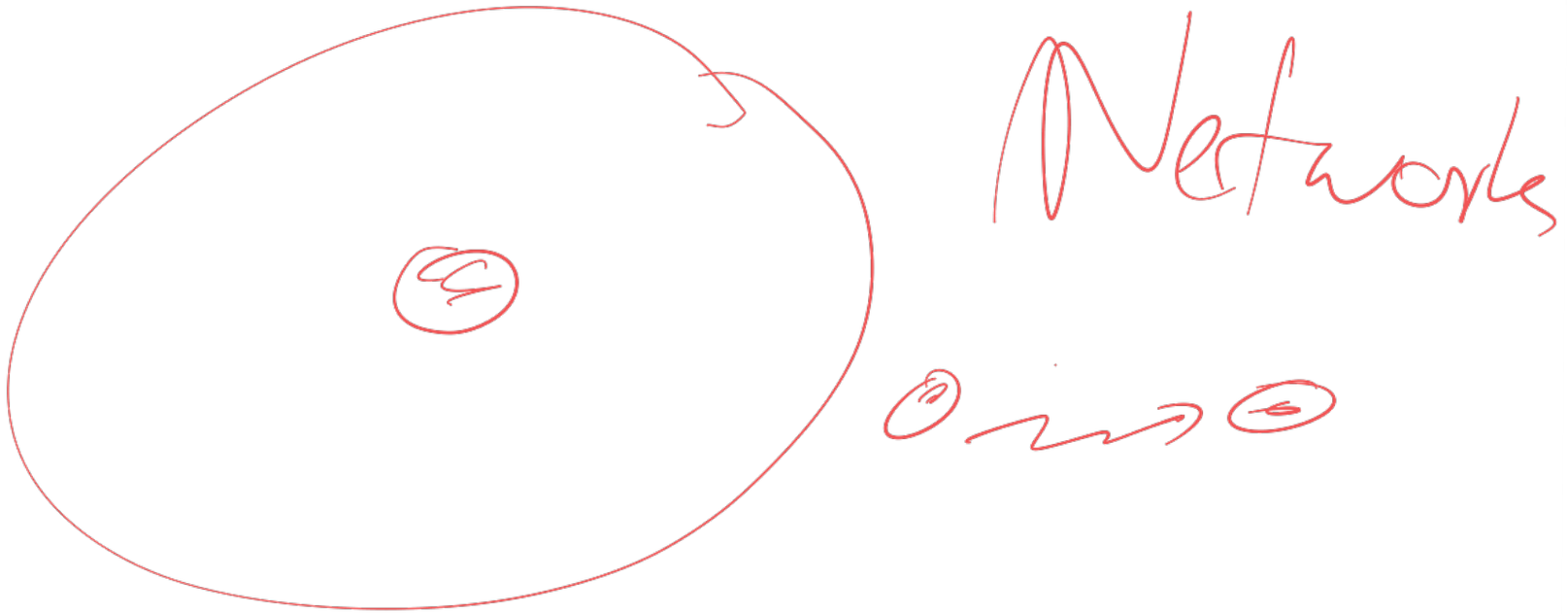
User interface and *communication* are inseparable...

- At very least it's communication between users and the thing
- Because we make the things intelligent, they are now can communicate among them to
  - Inform others about something...
  - Help each others or work together...

vDeSi
embedding the intelligence

Wireless communication ability becomes a norm to all intelligent systems...

- Intelligent systems represent information in form of *electrical signals*..
- Needs of wires for moving electrical signals...
- Electromanetic waves help get rid of the wires...



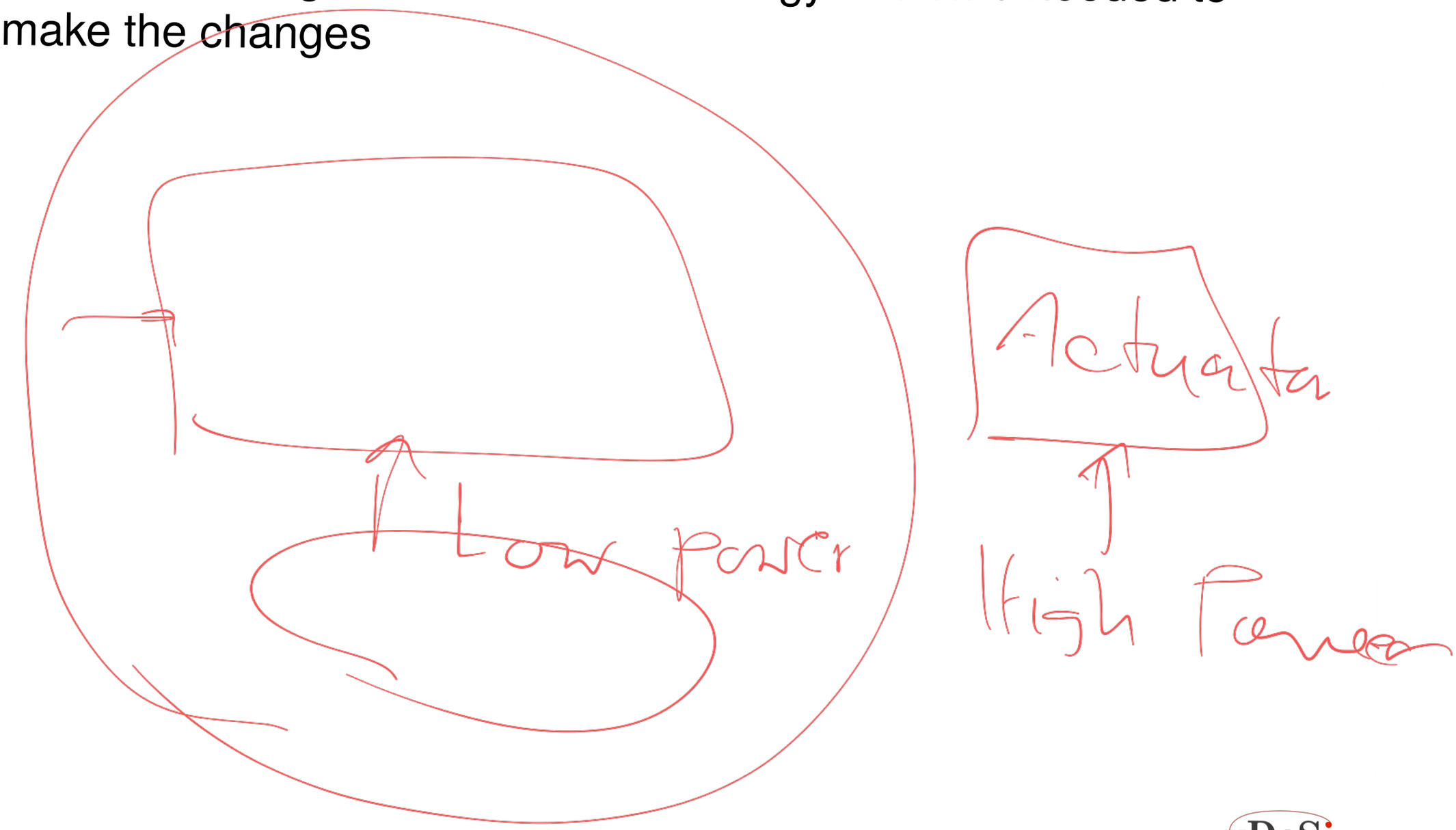
vDeSi
embedding the intelligence

Outline

vDeSi
embedding the intelligence

Any *"change"* needs *energy with enough power* and *time*...

- Thinks of changes and amount of energy and time needed to make the changes



vDeSi
embedding the intelligence

All units in an intelligent system require *power supply*, which provides energy with enough power...

- All units are designed to do a job..$\Rightarrow$ to make some changes..
- There exist *optimal points of energy and time* for any change..
- The *BIG challenge* for power supply is the *availability* of them at when needed..
- This leads to the following issues
  - Energy storage
  - Power havester
  - Low-power design of things

vDeSi
embedding the intelligence

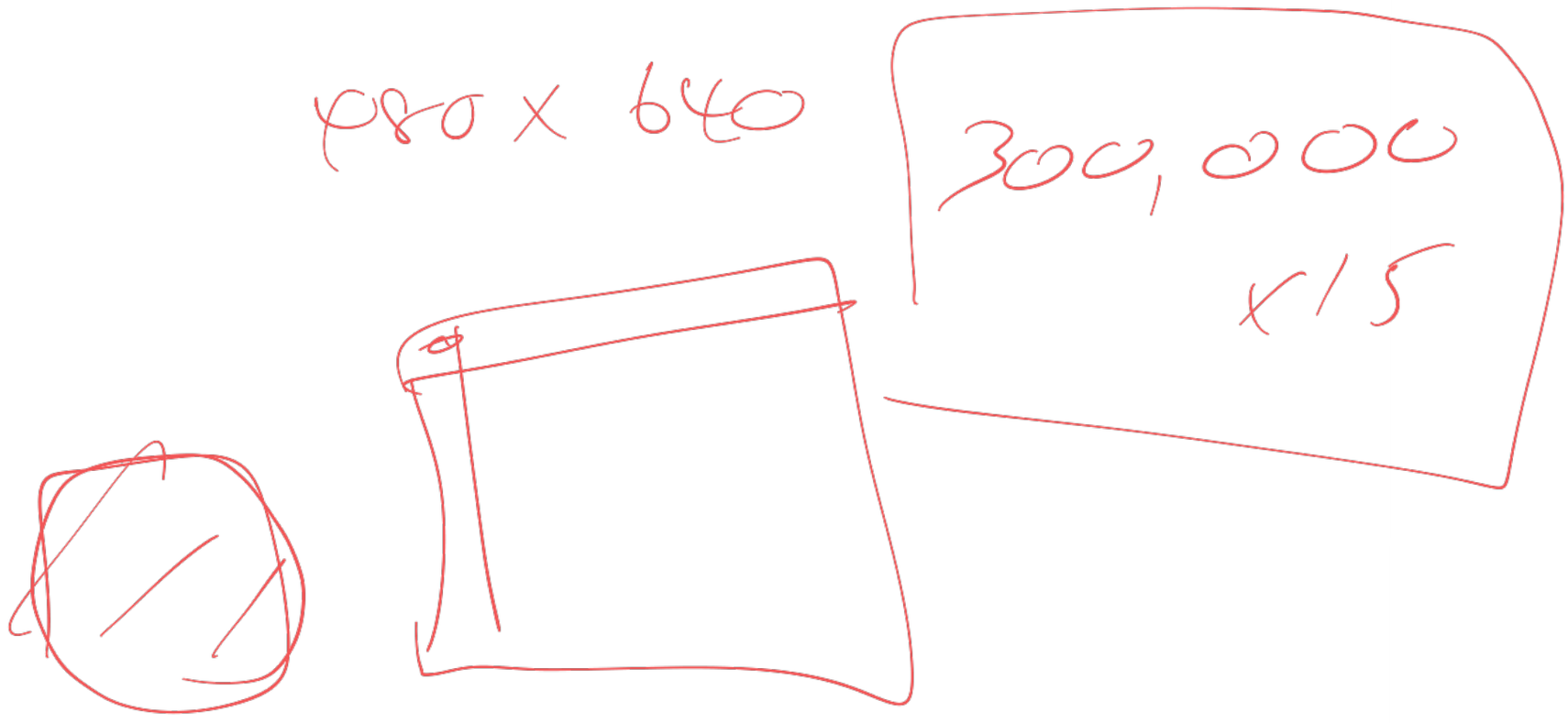
Outline

vDeSi
embedding the intelligence

The challenges of design and developing a intelligent system's brain depend on its *level of intelligence*...

Think about the following products in term of *level of intelligence* in the past 10 years

- A car...
- A phone...
- A rice cooker...
- A watch...

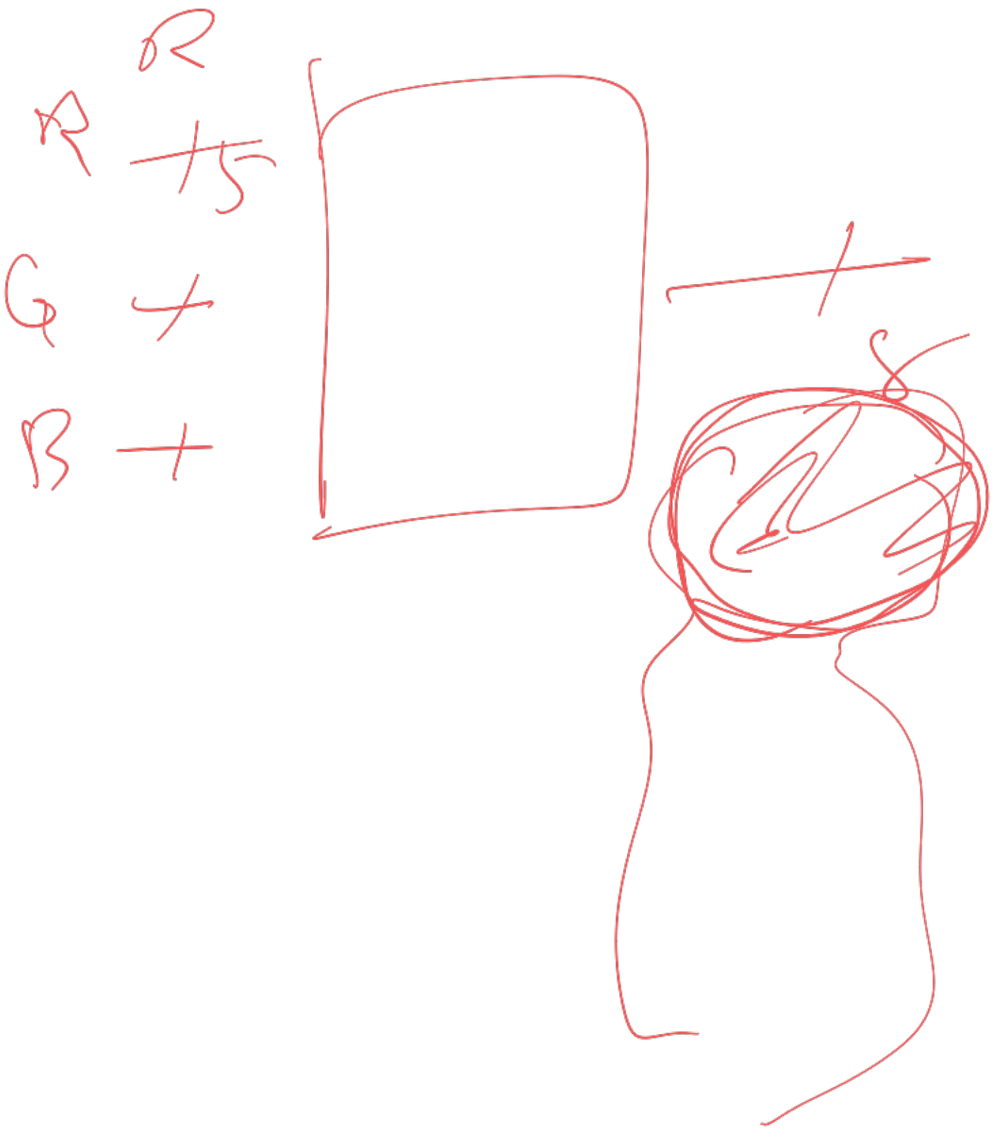


vDeSi
embedding the intelligence

The *level of intelligence* depends on the *ability to make decisions*, which inturn depends on the *algorithms*...

Think about the following products in term of *algorithms* that make it intelligent..

- Social media...
- Rice cooker...
- Air conditioner...
- A room...



vDeSi
embedding the intelligence

Algorithms depends on the *computing agents*, the *hardware* that must *perform the computations* required in the algorithm...

- Computing hardware is effectively implemented by *digital systems*...
- Digital systems are *electronic systems*...
- Most *electronic systems (circuits)* are implemented in *Integrated Circuits (ICs)*...
- Effects of IC technology is *HUGE*...
- *CMOS (Complementary MOSFET)* is the most influencial IC technology..
- The CMOS is reaching (has reached) its *limitation*...

vDeSi
embedding the intelligence

Any algorithm can be implemented as *software* or *hardware*...

- *Software implementations* need *hardware platform*...
- Both need some *development cost*, *design*, *verification*, *test*, and others cost
- The most important *factor* is the *time*... $\Rightarrow$ Less development time $\Rightarrow$ less cost...
- But hardware implementation has the ability to do things *faster with less energy (or power)*
- The general engineering principle is to choose implementation that can do as *specified* with *minimal cost*...
- Hence, *hardware-software codesign*...

vDeSi
embedding the intelligence