

# INTRODUCTION TO WIRELESS SENSOR NETWORKS

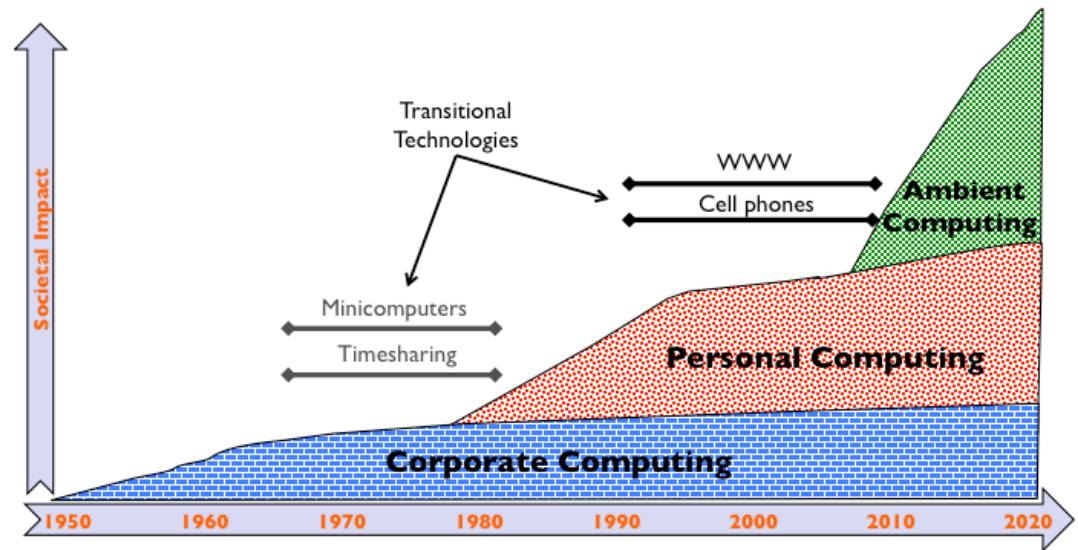
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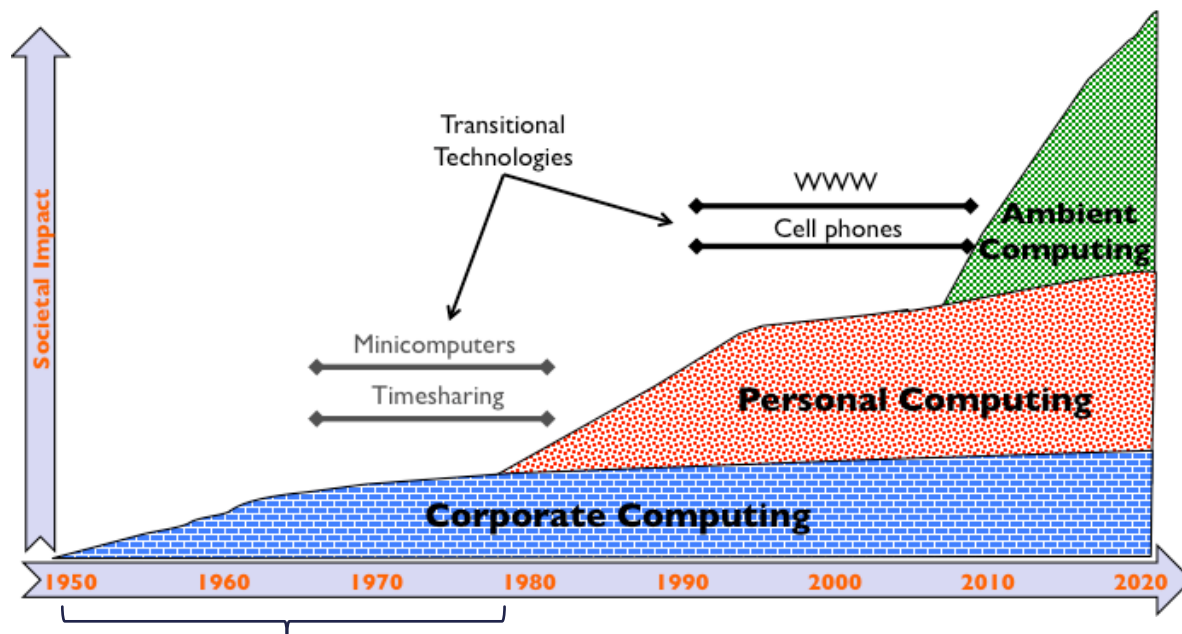
# AGENDA

- 3 ERA OF COMPUTING
- WHAT ARE WIRELESS SENSOR NETWORKS?
- TYPICAL SCENARIOS AND APPLICATIONS
- DESIGN CHALLENGES
  - Locally Available Resources
  - Diversity and Dynamics
  - Needed Algorithms
  - Dependability

# 3 ERA OF COMPUTING

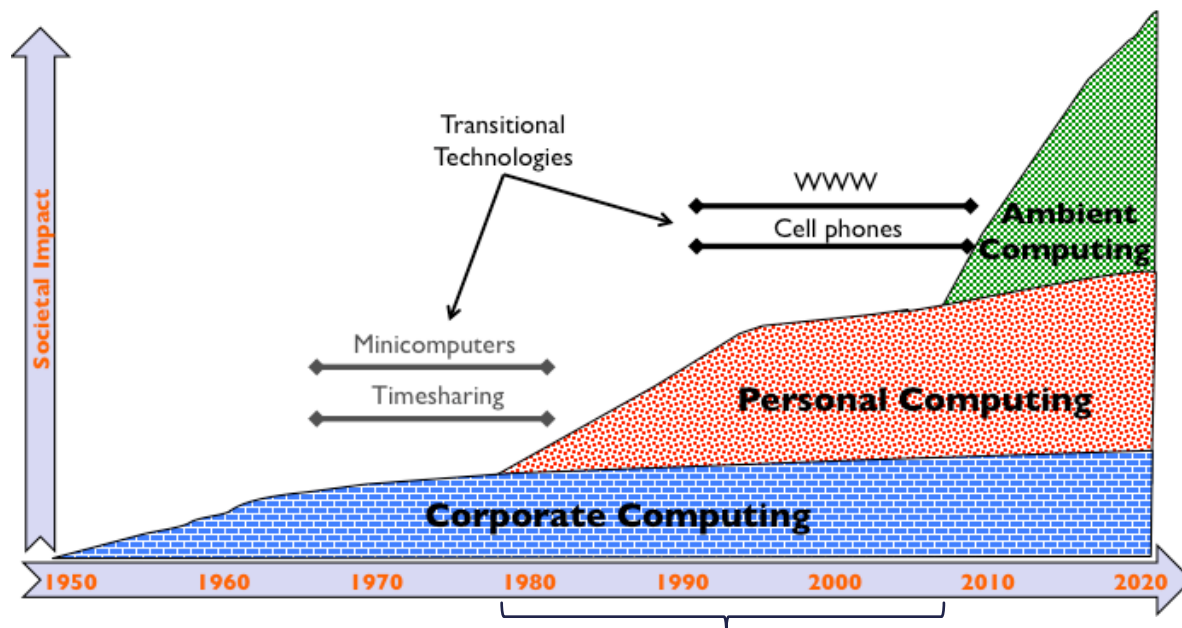
- Each of these eras represents a major difference in the role computers play in human life and society.
- The three eras also correspond to major shifts in the dominant form of computing devices and software.





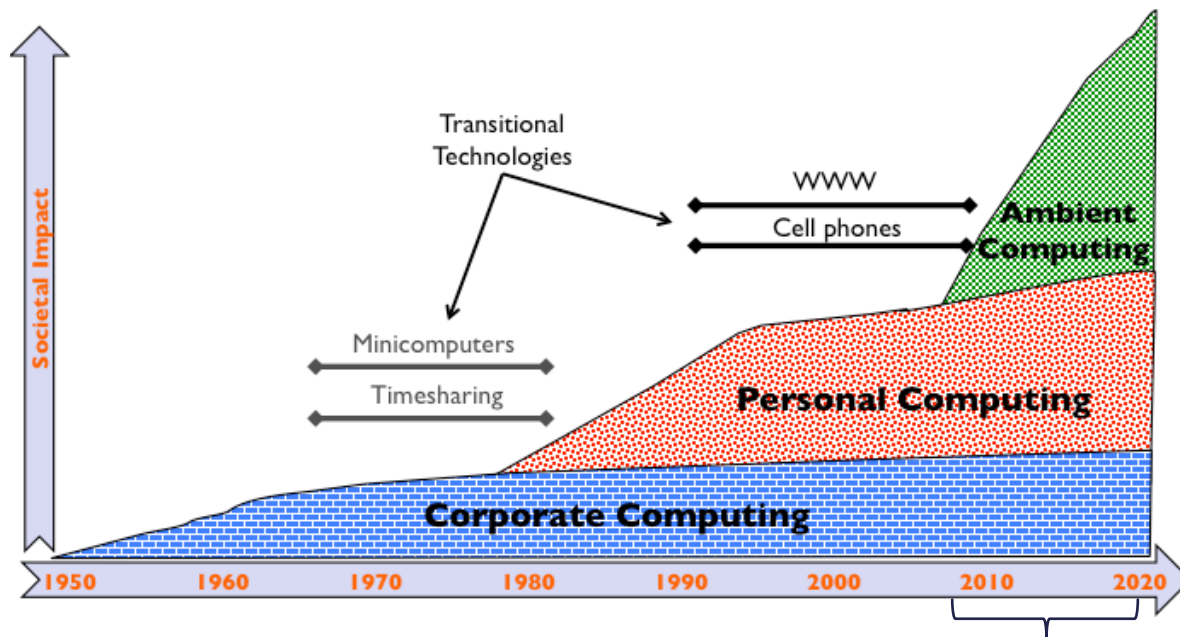
## FIRST ERA

- The *Corporate Computing Era*
- To enhance and empower large organizations (commercial enterprises and governments)
- Share mainframe among
- High cost to provide
- Huge maintenance cost



## SECOND ERA

- *Personal Computers Era*
- *Cheaper*
- *Smaller*
- *Affordable*
- *Average user has access more than one*
- *Rise of internet usage*
- *Cell Phones*



## THIRD ERA

- No universally accepted name. Some people call it post-PC, cloud, mobile, IoT, or web computing
- Desktop computers tend to be replaced by laptops and other **portable devices**
- Smart Phones / PDA

# WHAT IS WIRELESS SENSOR NETWORK?

- Any collection of devices equipped with
  - Processor
  - Sensing and Communication capabilities
  - Being able to organize themselves into a network created in an AdHoc manner
- Wireless communication capability increases functionality of sensors dramatically.
- Wireless sensor networks are one of the most important tools of the third era of computing.
- Help simple intelligent devices around which their main purpose is monitoring the environment, alerting us of the events happening.

# TYPICAL SCENARIOS AND APPLICATIONS

Classification based on the complexity of the networks:

- "Intelligent" warehouse
  - item to be monitored inside a warehouse is "tagged" with a small device
  - tags are monitored by the fixed sensor nodes embedded into the walls and shelves
- Environmental monitoring
  - Disaster monitoring category
  - Help humans estimate the effects of the disaster, build maps of the safe areas
- Very large-scale sensor networks applications
  - scenario of a large city where all the cars have integrated sensors
  - sensor nodes communicate with each other collecting traffic information, routes, and special traffic conditions



# TYPICAL SCENARIOS AND APPLICATIONS

Classification based on their area of application

- Military applications
- Environmental applications
  - Several aspects of the wildlife are being studied (movement of birds, animals, and even insects)
- Healthcare applications
  - An increasing interest is being shown to the elder population (in home and hospitals)
- Home applications
  - Home security devices
- Other commercial applications

# ESP32

## DEBO JT ESP32 Development boards ESP32 Wi-Fi and Bluetooth module

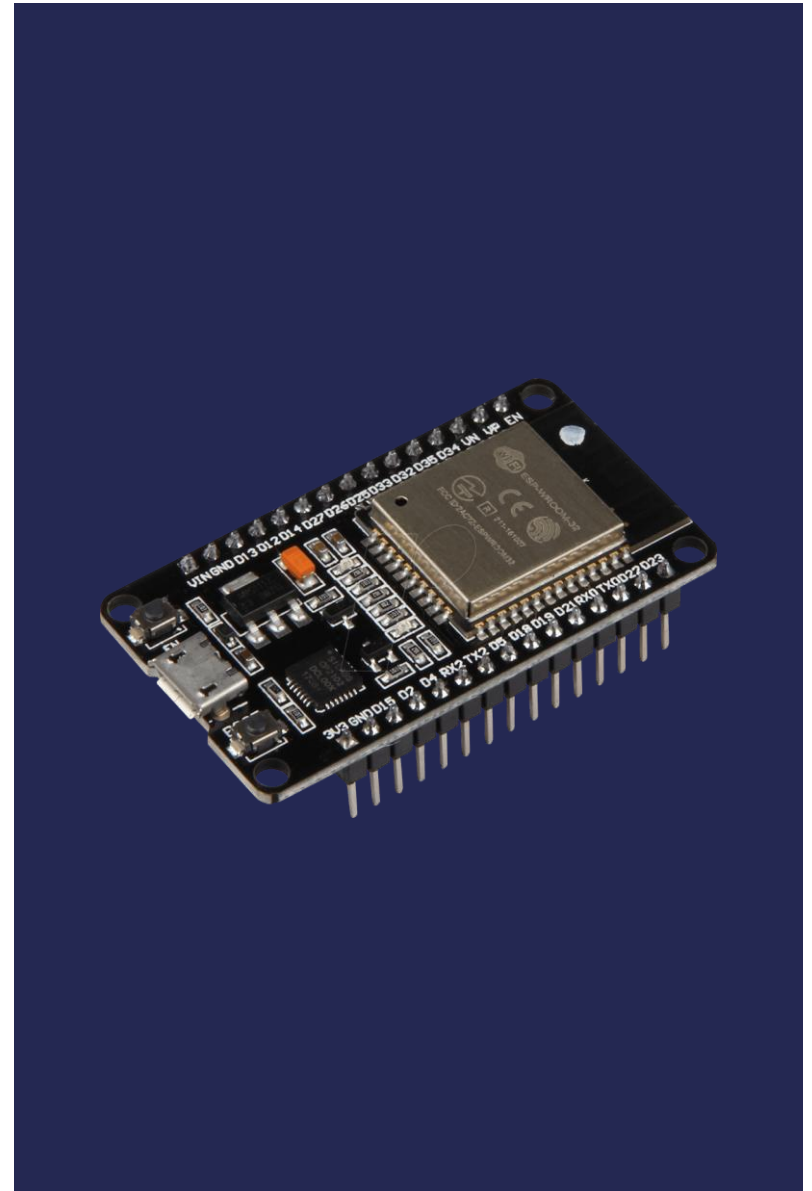
Wireless standard: 802.11 b/g/n

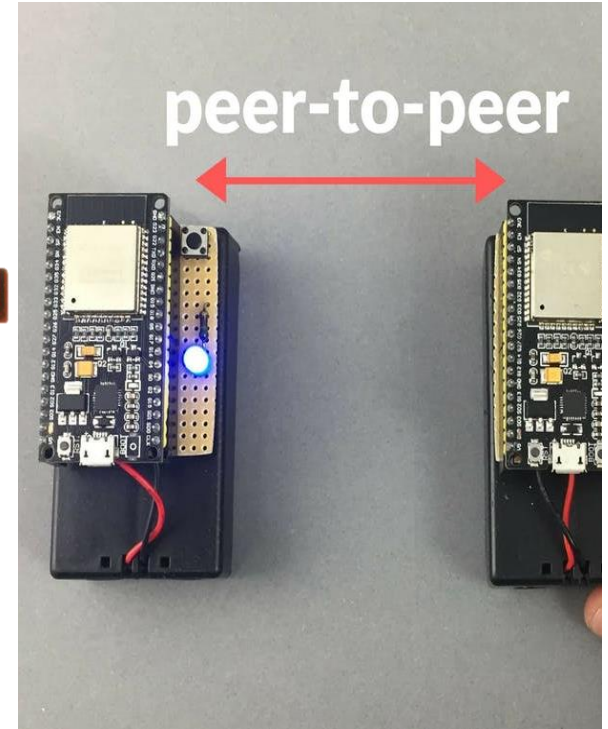
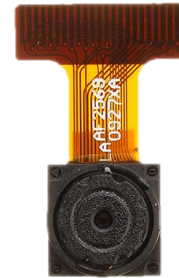
Frequency: 2.4 GHz

Bluetooth: Classic / LE

Operating voltage: 3.3 V (can be operated via 5-V micro-USB)

Operating temperature: -40 to 125°C





# SMALL & CAPABLE

<https://robotzero.one/esp32-camera-module/>

<https://www.hackster.io/donowak/esp32-to-esp32-communication-over-the-internet-9799df>

# DESIGN CHALLENGES

High-level description of Design Goals:

- Long life
  - The sensor node should be able to "live" as long as possible using its own batteries.
  - The targeted lifetime of a node powered by two AA batteries is a couple of years.
- Small size
  - The size of the device should be less than  $1 \text{ mm}^3$
- Inexpensive
  - To encourage large scale deployment, this technology must be really cheap, meaning that the targeted prices in the range of **a couple of cents**.

## DESIGN CHALLENGES

# LOCALLY AVAILABLE RESOURCES

Small size comes with the disadvantage of very limited resources availability

- Limited processing power
- Low-rate unreliable wireless communication
- Small memory footprint
- Low energy - the most important design constraint.

So:

- Each components must be optimized to obtain minimum energy consumption.
- Spend all the idle time in a deep power down mode.
- When active, employ scheduling schemes that take into consideration voltage and frequency scaling.

# DIVERSITY AND DYNAMICS

## **Diversity:**

There may be several kinds of sensor nodes present inside a single sensor network. Combining sensing parameters from different sensors and then make a single decision (data-fusion).

For example: To detect if fire has started:

- Light
- Temperature
- Smoke, etc.

**Dynamic:** Sensor nodes are to be deployed in the real world, most probably in harsh and dynamic environments.

- Influence on the algorithms
- Failures at random times
- Change their transmission range to better suit their energy budget

## DESIGN CHALLENGES

# DEPENDABILITY

More than any other sort of computer network, the wireless sensor networks are subject to failures.

- High probability of failure
- Algorithms must employ some form of robustness in front of the failures
  - Effect on the energy, memory cost, so it must keep failures at a minimum.
- This scenario hardly ever happens simultaneously *for all the layers* and a combination of lower layer protocols could eliminate such a scenario.
- The preferred approach is that of cross-layer designing and studying of the sensor node as a whole object rather than separate building blocks
- The medium will be an important factor to disturb the message communication
- Even with a perfect environment, collisions will occur due to the imprecise local time estimates and lack of synchronization.

## DESIGN CHALLENGES

# DEPENDABILITY

Another dependability attribute is **Security**:

- The communication channel is opened and cannot be protected.
- This means that others can intercept and to disrupt the transmissions or even to transmit their own data.
- In addition to accessing private information, a third party could also act as an attacker that wants to disrupt the correct functionality of the network.
- The usual protection schemes require too much memory and too much computation power to be employed (the keys themselves are sometimes too big to fit into the limited available memory)

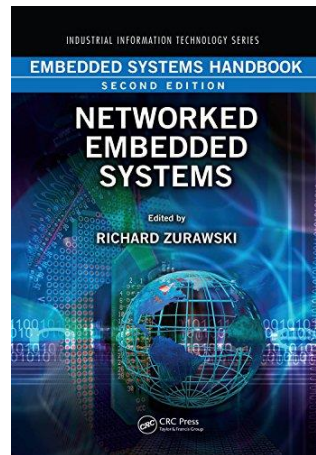


## NEXT

The following chapters of the book will focus on

- Particular Issues
- Giving more insight to the current state of the art approaches in this field.

# REFERENCE



Networked Embedded  
Systems  
by Richard Zurawski  
Chapter 3



THANK YOU

Q / A