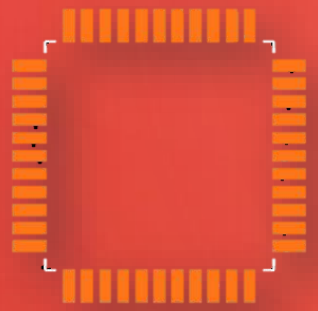

Interfacing

DIO layered architecture

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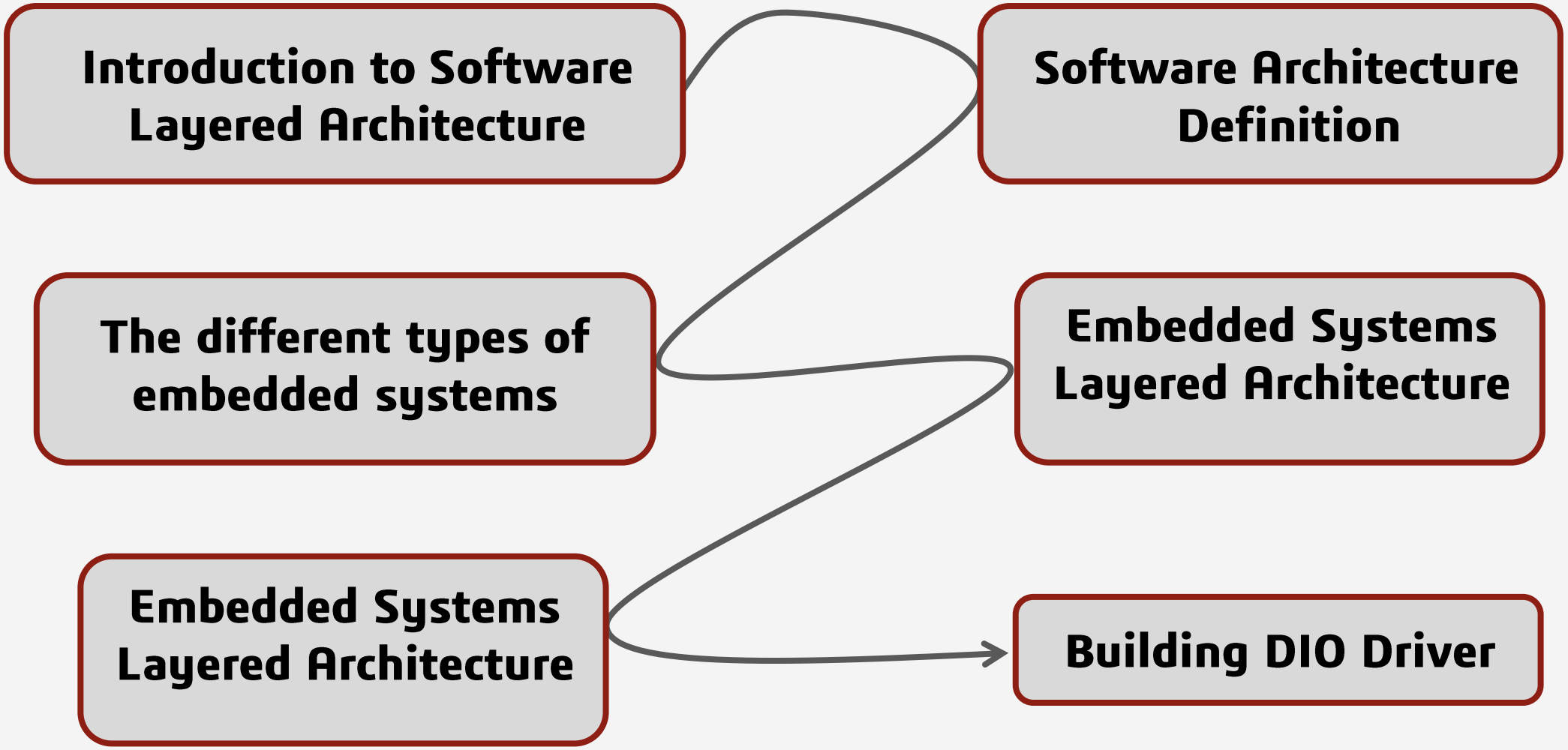
Content



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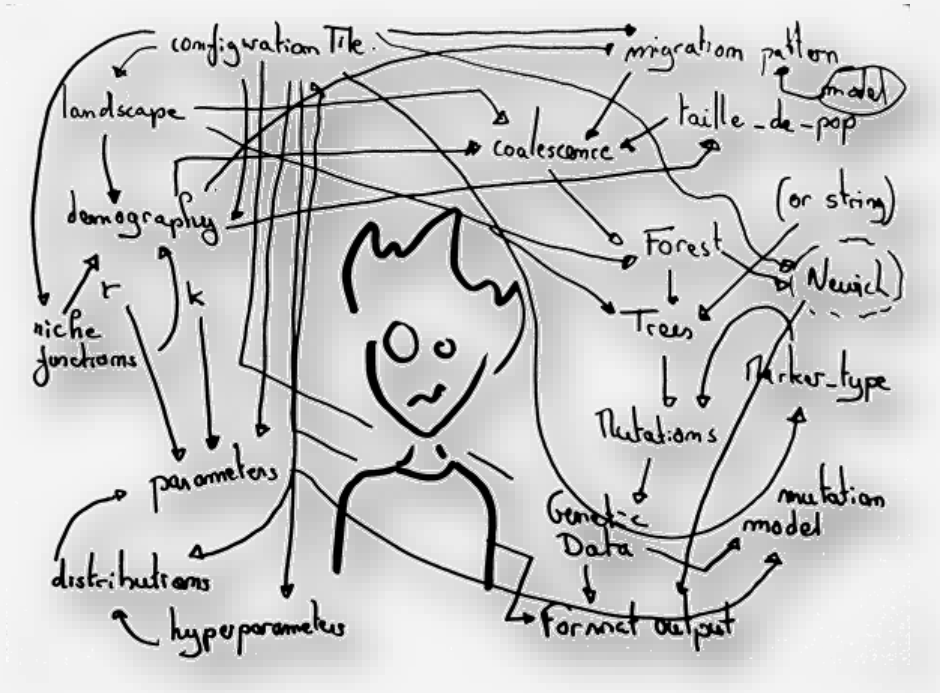
Introduction to Software Layered Architecture

Imagine having a source code file contains **10 thousands** lines of code. If you have a bug in this code, how complex is finding the bug ... ?



This is what's called **the Spaghetti Code**, which is the code that unstructured and difficult to maintain

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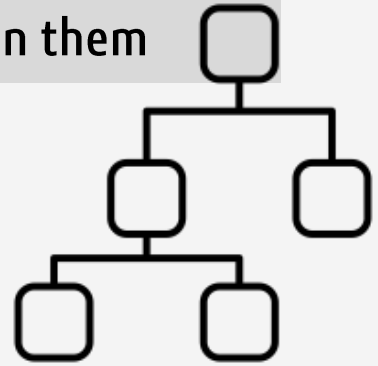
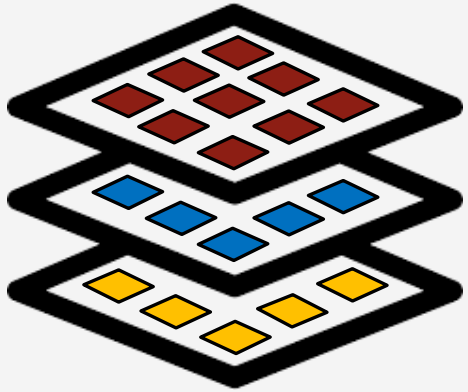
Embedded Systems Layered Architecture

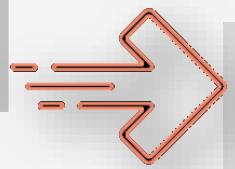
Definition **The software architecture** is a structuring way used to define software elements and relationships between them



In **Embedded Systems** we use a major type of software architecture called **Layered Architecture**

Layered Architecture In the layered architecture the software is divided into small parts called "Software Components**(SWC)**"





Software components related to each other are organized in a **horizontal layer**
Each layer is performing a **specific role**

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The different types of embedded systems

- Real-time embedded systems
- Standalone embedded systems
- Network, or networked, embedded systems
- Mobile embedded systems

Real-time embedded systems must provide results or outputs promptly.
Priority is assigned to output generation speed, as real-time embedded systems are often used in mission-critical sectors, such as defense and aerospace, that need important data

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The different types of embedded systems

- Real-time embedded systems
- Standalone embedded systems
- Network, or networked, embedded systems
- Mobile embedded systems

Standalone embedded systems don't require a host computer to function. They can produce outputs independently.

Examples:

- Digital cameras
- Digital wristwatches
- MP3 players
- Appliances, like refrigerators, washing machines
- Calculators

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The different types of embedded systems

- Real-time embedded systems
- Standalone embedded systems
- Network, or networked, embedded systems
- Mobile embedded systems

Network, or networked, embedded systems rely on wired or wireless networks and communication with web servers for output generation.

Frequently cited examples:

- Home and office security systems
- Automated teller machines (ATMs)
- Point-of-sale (POS) systems

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The different types of embedded systems

- Real-time embedded systems
- Standalone embedded systems
- Network, or networked, embedded systems
- Mobile embedded systems

Mobile embedded systems refer specifically to small, portable embedded devices, such as cellphones, laptops, and calculators.

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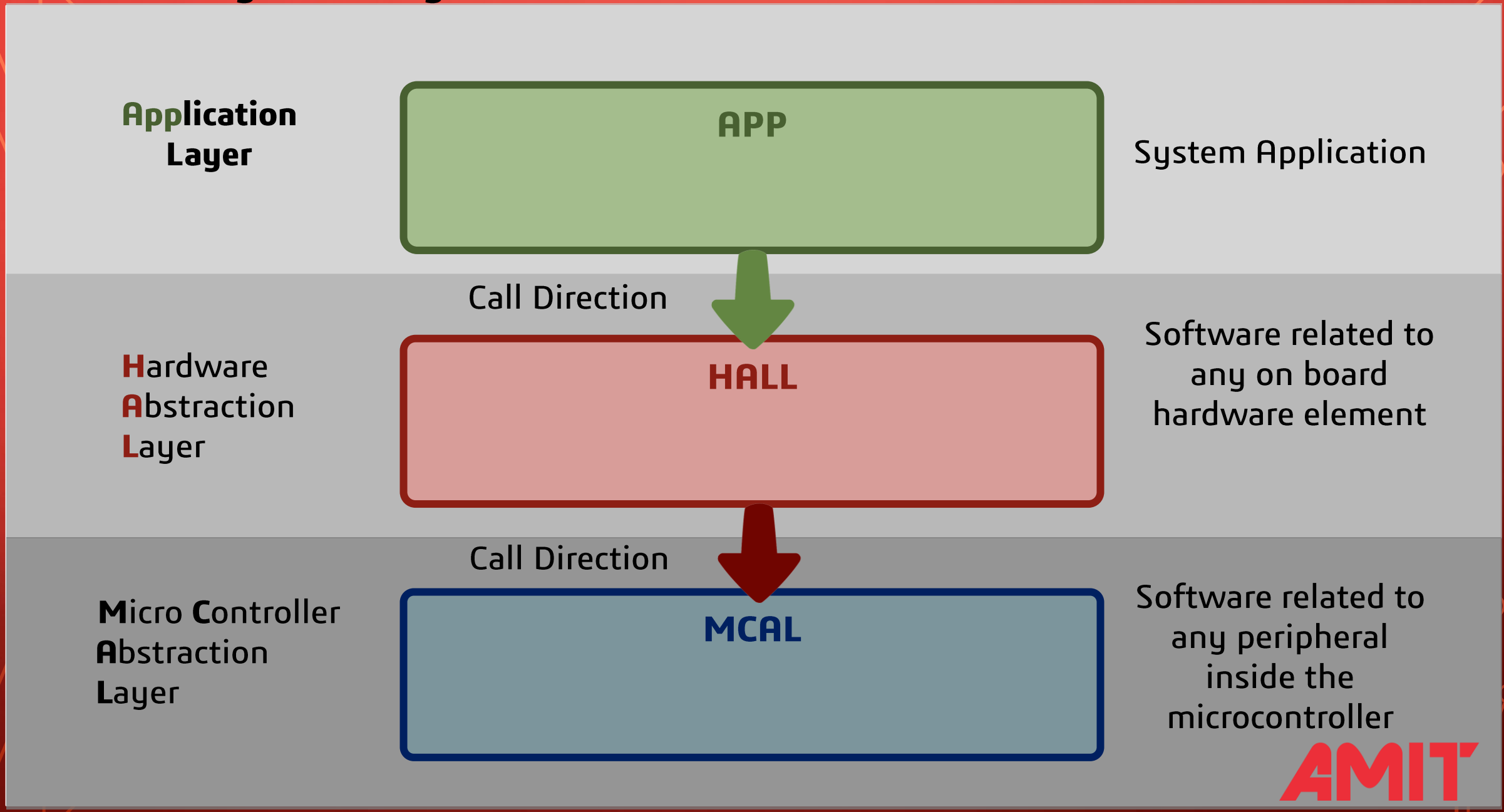
Embedded Systems Layered Architecture



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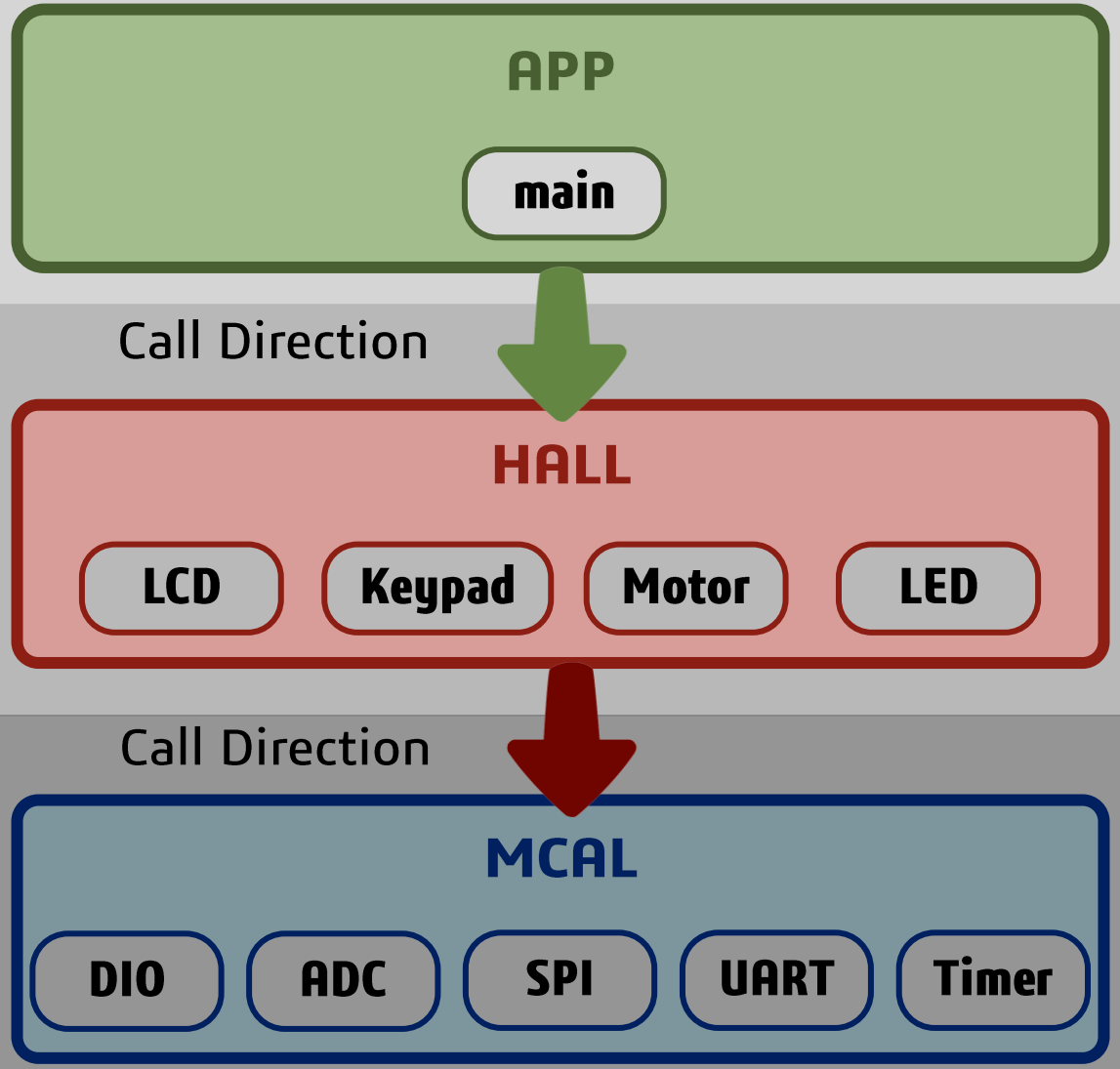
Embedded Systems Layered Architecture



System Application

Software related to any on board hardware element

Software related to any peripheral inside the microcontroller

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Embedded Systems Layered Architecture

Advantages of Layered Architecture

1. **Modularity**
   In a Layered architecture we separate the user application from the hardware drivers from the microcontroller specific drivers
2. **Portability**
   Changing any part of the software part would change its layer only. For example, if we need the same application with a new microcontroller, we shall only change the MCAL
3. **Maintainability**
   Debugging and **Testing** is now much easier in small parts of the software instead of having a very long and complex one
4. **Reusability**
   Code could be easily **reused** in different applications and systems.

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Building DIO Driver

The Simplest driver consists of only 2 files

Program_Source file
Program.c

Contains the implementations of the functions provided by the driver
EX: DIO_program.c

Header file
Program.h

contains the prototypes of the functions provided by the driver to be used by other SWCs that need to use this driver
Ex: DIO_interface.h

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Building DIO Driver

Lets think about the DIO_Driver " DIO_Program.c & DIO_Interface.h "

Remember

DIO

Stands for " Digital Input / Output ": Is a peripheral that deals with **digital signals**, either by generating a digital signal **(Output Mode)** or by receiving it **(Input Mode)**

We want to Implement APIs or Functions that allow us to:

- API to Set a PORT Direction
  - I/P
  - O/P
- API to Set a PIN Direction
  - I/P
  - O/P
- API to Read a PIN's Value
  - 1
  - 0
- API to Read a PORT's Value
- API to Toggle a PIN
  - High
  - LOW

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Building DIO Driver

DIO_Interface.h → We will Write the prototypes of the functions

```
//Function that can set the direction of a PORT( A, B , C , D ) as Output or Input
        void   DIO_Set_PORT_DIR( PORT ,   DIR  );

//Function that can set the direction of a PIN( 0----> 7 ) as Output or Input
        void   DIO_Set_PIN_DIR(  PORT ,   PIN ,   DIR  );

//Function that can set the value allover PORT( A, B , C , D ) by a value
        void   DIO_Set_PORT_VALUE( PORT ,  Val  );

//Function that can set the value of a PIN ( 0----> 7 ) to 0 or 1
        void   DIO_Set_PIN_VALUE( PORT ,  PIN  ,  Val  );

//Function that can read the value of the PORT( A , B , C , D )
        void   DIO_Read_PORT( PORT ,   *val  );

//Function that can read the value of the PIN ( 0----> 7 ) to 0 or 1
        void   DIO_Read_PIN (  PORT ,  PIN  ,  *val  );

//Function that can toggle the pin value o to 1 and 1 to 0
        void   DIO_Toggle_PIN (  PORT ,  PIN  );
```

Let's Go and Implement these functions

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Building DIO Driver

DIO_Program.c

```
/*Function that can set the direction of a PORT( A, B , C , D ) as Output
or Input */
void  DIO_Set_PORT_DIR( PORTx ,  DIRx  )
      {
```

" To control the mode of the pins of PORTx to be output or input "

- The only step that we want here to assign the value of the **Data Direction Register "DDRx"**
- To set the PORTx's Direction to be **an output**, We will set **"1"** to all the bits in that Register Assuming that we deal with ATmega32 and its architecture is 1 byte which equals to **8 bit**, so we will assign **0xff " 1111 1111 " in the Data Direction** Register, and then we will successfully put **"1"** in each bit **" DDRx = 0xff "**

- To set the PORTx's Direction to be **an input**, We will set **"0"** to all the bits in that so we will assign **0x00 " 0000 0000 "** in the Data Direction Register , and then we will successfully put **"0"** in each bit **" DDRx = 0x00 "**

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Building DIO Driver

DIO_Program.c

- We will create a conditional statement to allow us to access to the actual location for the PORT selected and then, select the desired direction

- switch(PORT)
  case: PORTA
  DDRA = Dirx
  case: PORTB
  DDRB = Dirx
  - - - - - - - -
  - - - - - - - -
  - - - - - - - -
  - - - - - - - -
  }

1 For Output

DIRx

0 For Input

B C

A PORTx D

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Building DIO Driver

DIO_Program.c

```
/*Function that can set the direction of a PIN( 0----> 7 ) as Output or Input*/
void   DIO_Set_PIN_DIR( PORTx , PINx ,  DIR  )
        {
```

" To control the mode of the PINx to be output or input "

- The only step that we want here to assign the value of the **Data Direction Register "DDRx"**
- To set the PINx Direction to be **an output**, We will set **"1"** to the corresponding bit in that Register

" DDRx = the corresponding bit for the pin selected "

- To set the PINx Direction to be **an input**, We will set **"0"** to the corresponding bit in the **Data Direction Register "DDRx"**

" DDRx = the corresponding bit for the pin selected "

```
        }
```

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Building DIO Driver

DIO_Program.c

- We will create a conditional statement to check the direction an then we will switch between the PORTs to set the desired PIN

```
switch(Dir)
 case: OUTPUT
     switch(PORT)
         case: PORTA
          Set_Bit(DDRA , PINx)
         case: PORTB
          Set_Bit(DDRB , PINx)
              - - - - - - - -
              - - - - - - - -
              - - - - - - - -
              - - - - - - - -
   case: INPUT
    switch(PORT)
         case: PORTA
         CLR_Bit(DDRA , PINx)
         case: PORTB
         CLR_Bit(DDRB , PINx)
              - - - - - - - -
              - - - - - - - -
              - - - - - - - -
}             - - - - - - - -
```

1 For Output

DIRx

0 For Input

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Building DIO Driver

DIO_Program.c

```
//Function that can set the value allover PORT( A, B , C , D ) by a value
void   DIO_Set_PORT_VALUE( PORT ,  Val )
{
```

- We will create a conditional statement to allow us to access to the actual location for the PORT selected and then, will assign the desired value

- switch(PORT)

```
 case: PORTA
 PORTA = val
 case: PORTB
 PORTB = val
 - - - - - - - -
 - - - - - - - -
 - - - - - - - -
 - - - - - - - -
}
```

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Building DIO Driver

DIO_Program.c

```
//Function that can set the value of a PIN ( 0----> 7 ) to 0 or 1
void  DIO_Set_PIN_VALUE( PORT , PIN , Val )
{
```

- We will create a conditional statement to allow us to access to the actual location for the PORT selected and then, will assign the desired value to the selected PIN in its register

- switch(PORT)
  case: PORTA
  PINA = val
  case: PORTB
  PIN = val

- - - - - - - -
- - - - - - - -
- - - - - - - -
- - - - - - - -

```
}
```

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Building DIO Driver

DIO_Program.c

```
        //Function that can read the value of the PORT( A , B , C , D )
void   DIO_Read_PORT( PORT ,   *val  )
{
```

- We will create a conditional statement to allow us to which PORT selected and then, will can read the actual value to the its PINx into val

- switch(PORT)
  case: PORTA
  *val = PINA
  case: PORTB
  *val = PINB

```
}
```

Building DIO Driver

DIO_Program.c

```
//Function that can read the value of the PIN ( 0----> 7 ) to 0 or 1
void  DIO_Read_PIN ( PORT , PIN ,  *val  )
{
```

- We will create a conditional statement to allow us to which PORT selected and then, will can get the actual value of the selected PINx into val

- switch(PORT)

```
 case: PORTA
 *val = Get_BIT(PINA, Pin)
 case: PORTB
  *val = Get_BIT(PINB, Pin)
 - - - - - - -
 - - - - - - -
}  - - - - - - -
 - - - - - - -
```

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Building DIO Driver

DIO_Program.c

```
        //Function that can toggle the pin value o to 1 and 1 to 0
void   DIO_Toggle_PIN ( PORT , PIN )
{
```

- We will create a conditional statement to allow us to which PORT selected and then, will can toggle the actual value of the selected PINx

- switch(PORT)
  case: PORTA
  Toggle_BIT(PORTA, Pin)
  case: PORTB
  Toggle_BIT(PORTB, Pin)

```
        }
```

THANK YOU!

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