Introduction To OSEK OS

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Introduction To OSEK OS

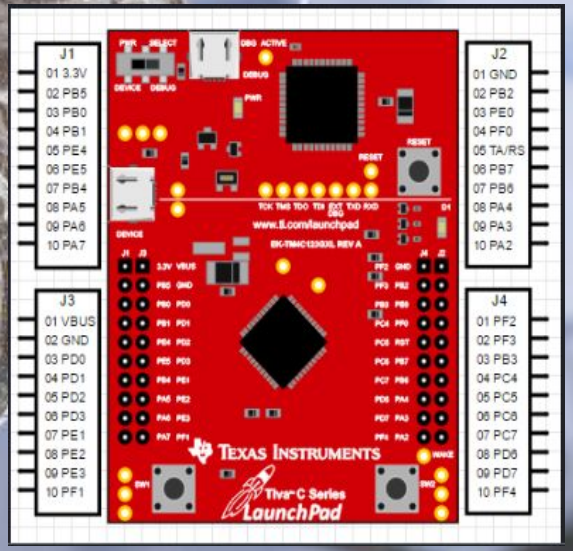
Prerequisites:

- **Basics of C programming**
- **Simple background in MCU programming**
- **Simple background in RTOS concepts**

Introduction To OSEK OS

Hardware & Tools:

- Keil Uvision 5
- Tiva C Launchpad
- VSCode or Notepad++ for code editing



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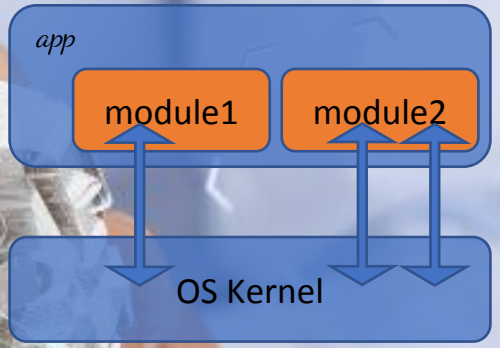
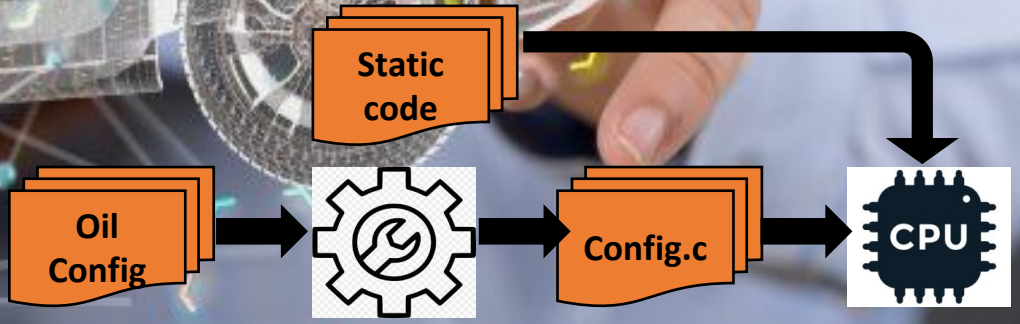
What is OSEK?

- small, scalable RTOS.
- Standard interfaces between the app and the OS.
- Different conformance classes, various scheduling mechanisms
- Statically scaled/configured at the system generation time





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OSEK Features

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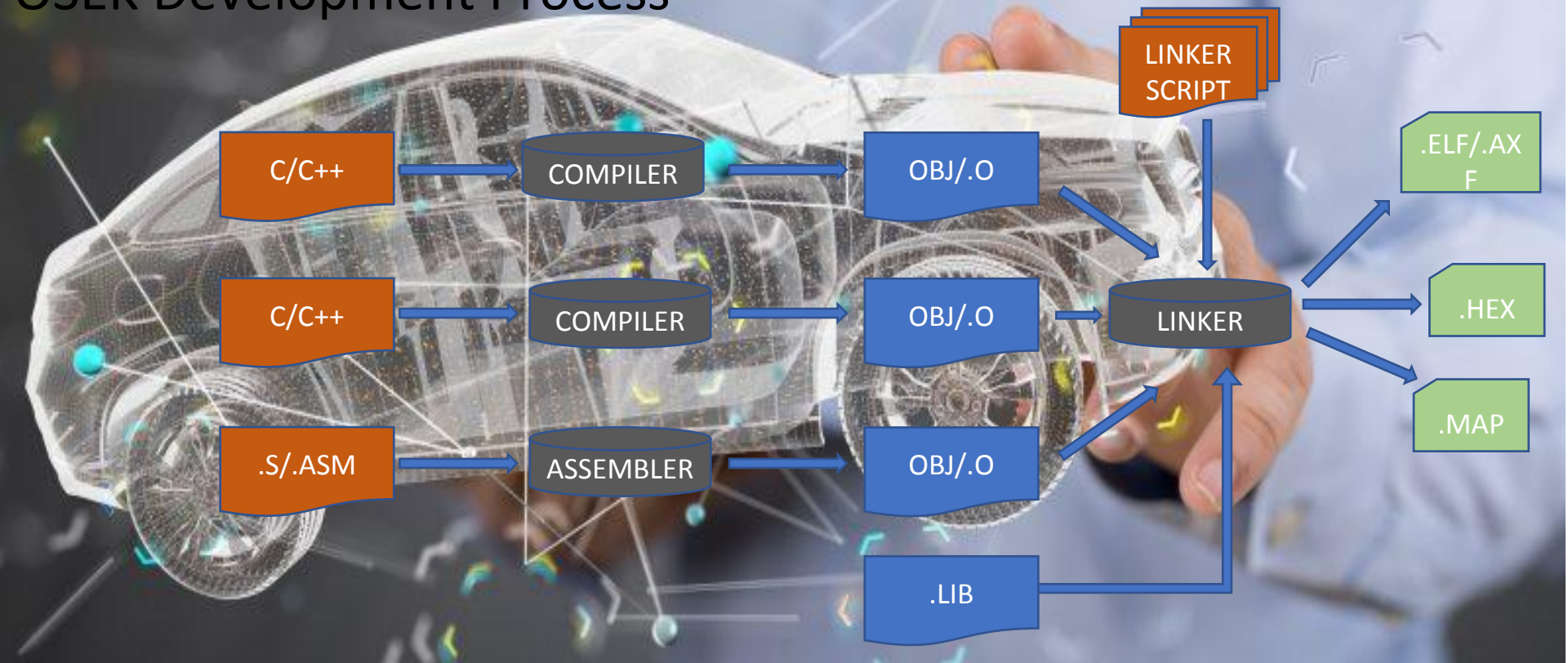
OSEK Development Process



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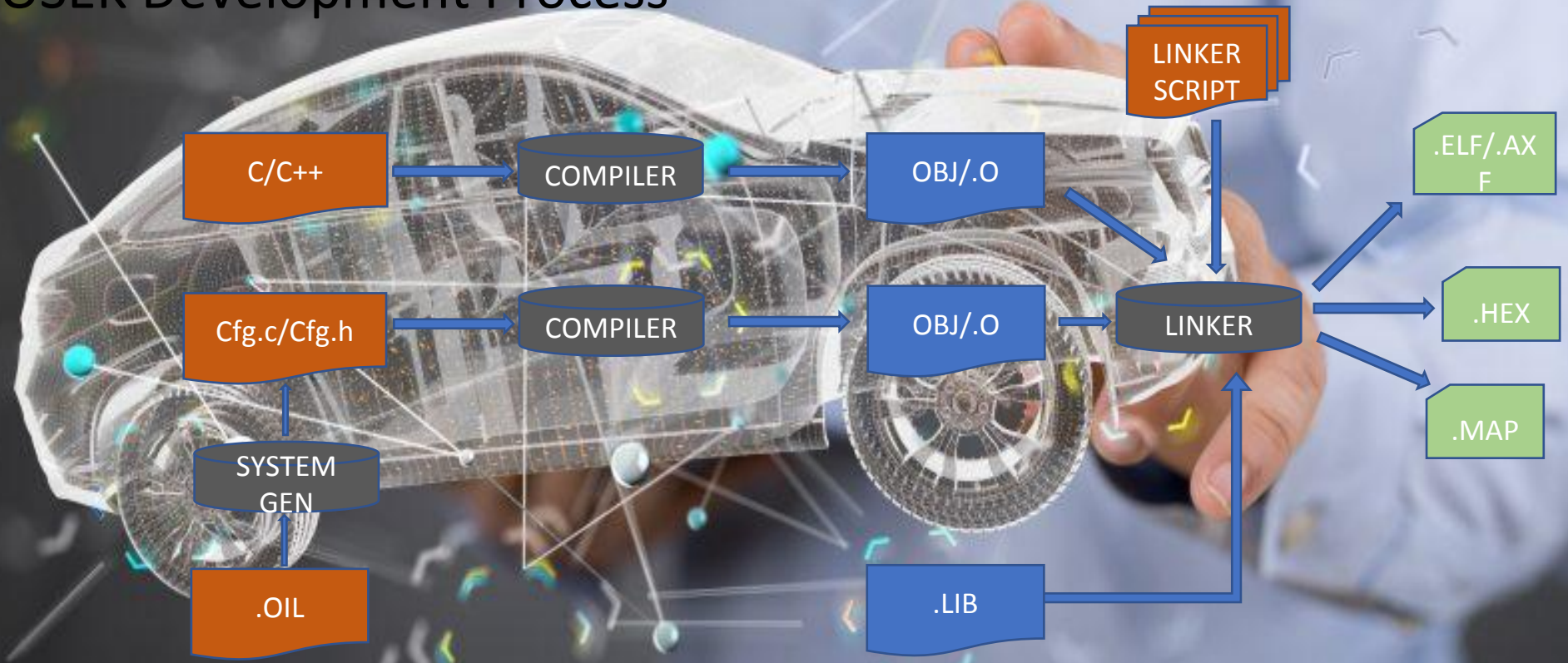
OSEK Development Process



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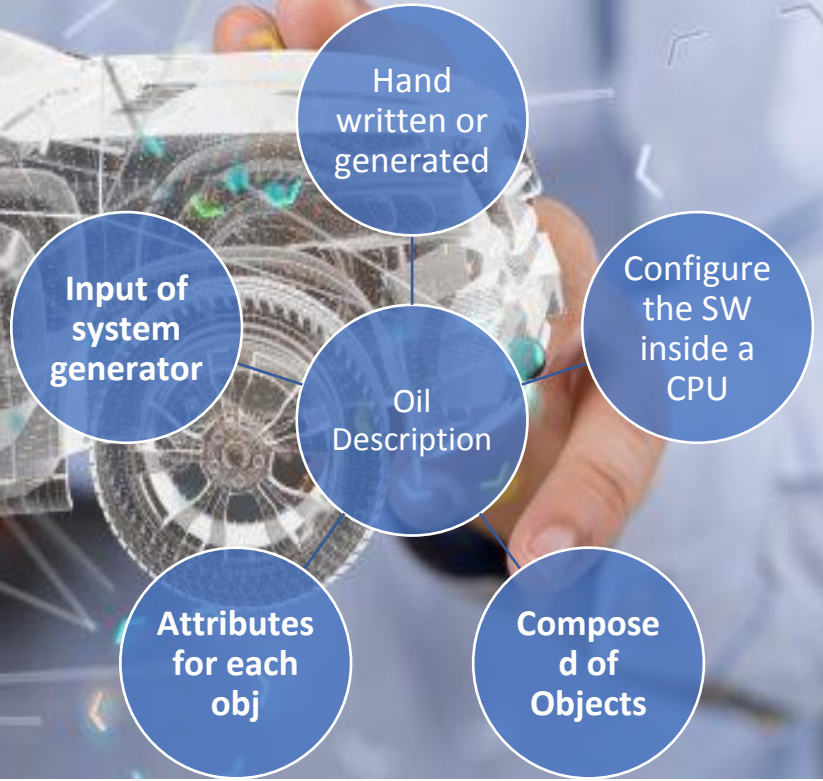
OSEK Implementation Language (OIL)

```
CPU CORTEX-M4 {
        OS OSEKOS {
                STATUS = EXTENDED ;
                ...
        };
        TASK MyTask{
                PRIORITY = 45;
                SCHEDULE = NON;
                ...
        }
        RESOURCE ResourceExample{
                RESOURCEPROPERTY = STANDARD;
        }
        ...
        ...
}
```



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OSEK Implementation Language (OIL)

```
CPU CORTEX-M4 {
    OS OSEKOS {
      STATUS = EXTENDED ;
            STARTUPHOOK = FALSE;
      ERRORHOOK = FALSE;
      STACKOVERFLOWHOOK = TRUE;
      SHUTDOWNHOOK = FALSE;
      PRETASKHOOK = TRUE;
      POSTTASKHOOK = TRUE;
      USEGETSERVICEID = FALSE;
      USEPARAMETERACCESS = FALSE;
      USERESSCHEDULER = FALSE;
      SYSTEMTICKMS = 10
    };
```

```
TASK TaskA {
      PRIORITY = 10;
      SCHEDULE = FULL;
      ACTIVATION = 1;
      AUTOSTART = TRUE {APPMODE = AppMode1;};
      STACKSIZE = 50;
```

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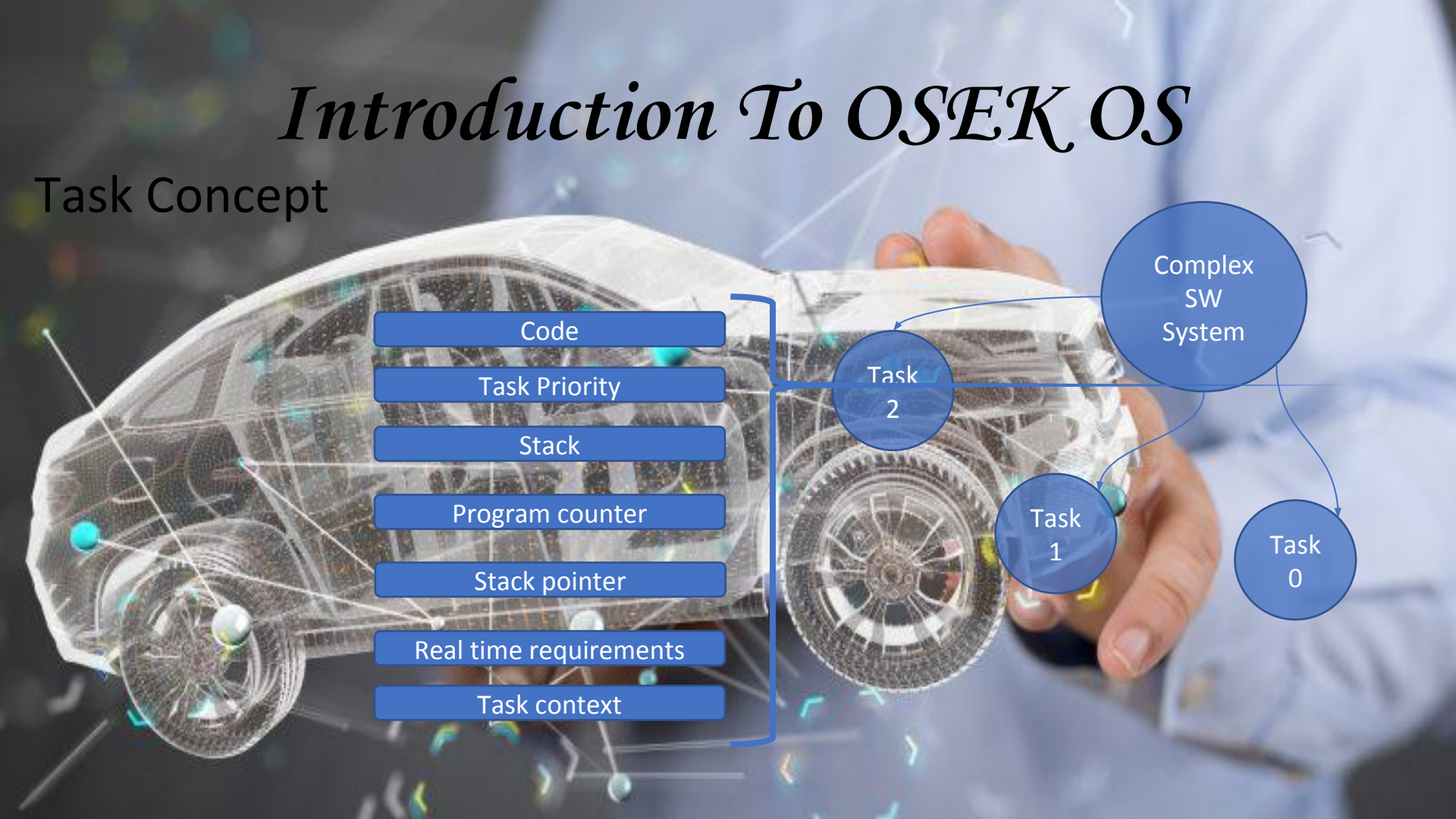
Task Concept



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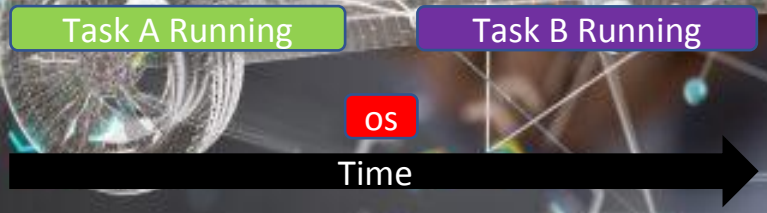
OSEK Task Management

TASK ShapeUpdate{

PRIORITY = 10;

SCHEDULE = FULL/NON;



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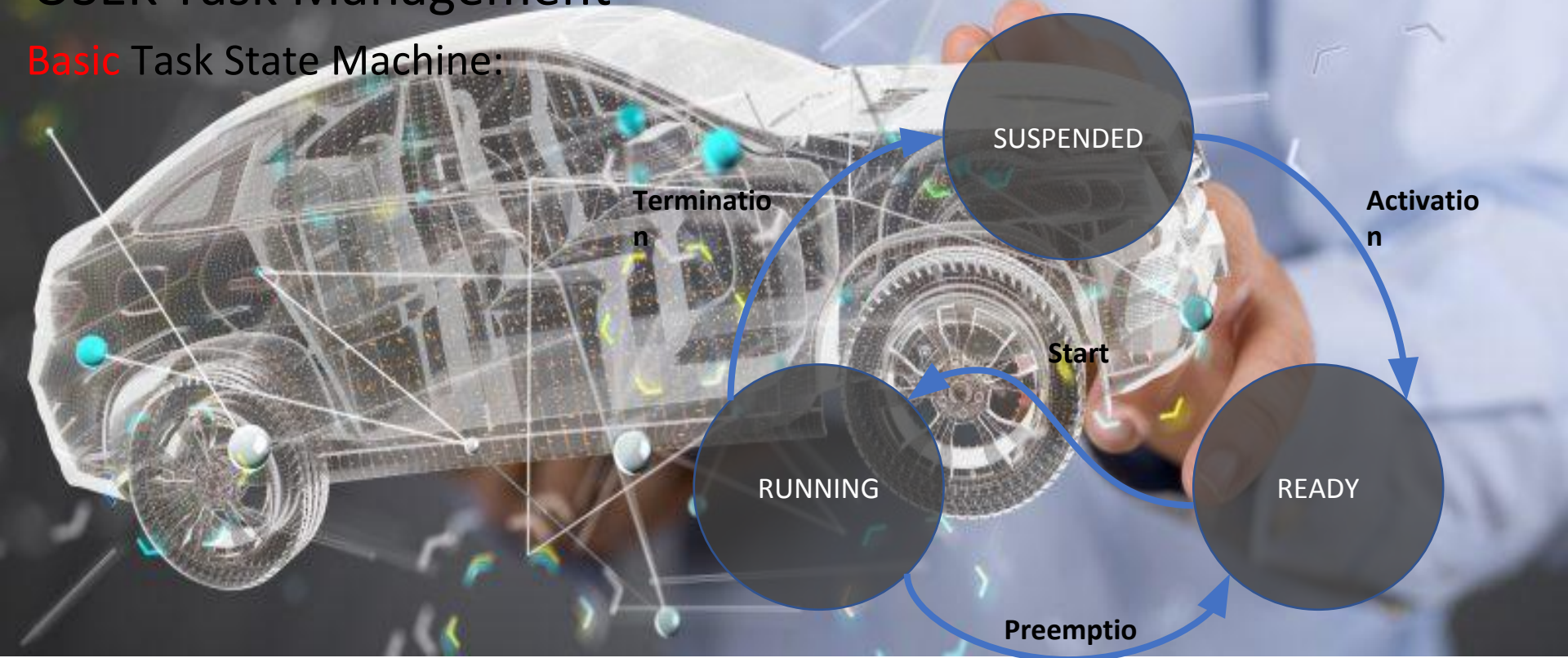
OSEK Task Management

Basic Task State Machine:



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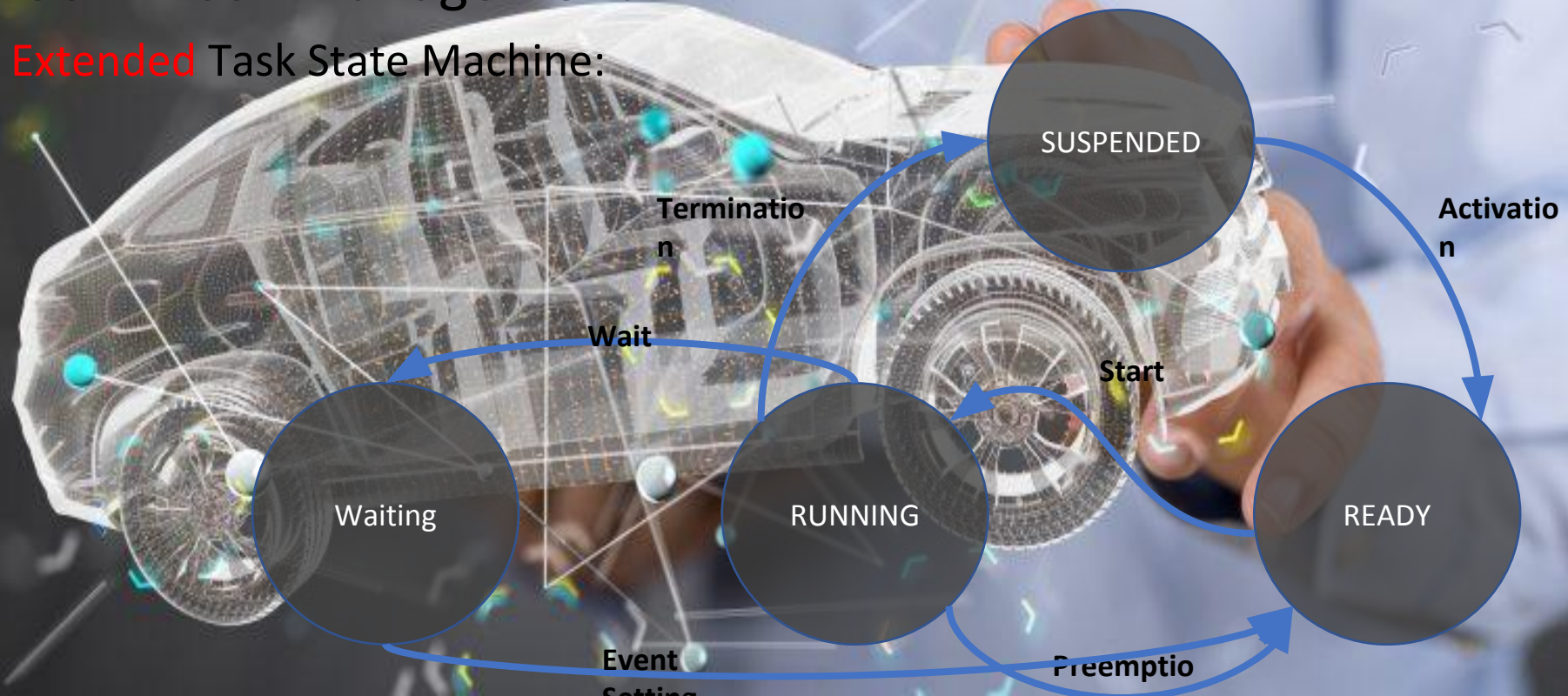
OSEK Task Management

Extended Task State Machine:



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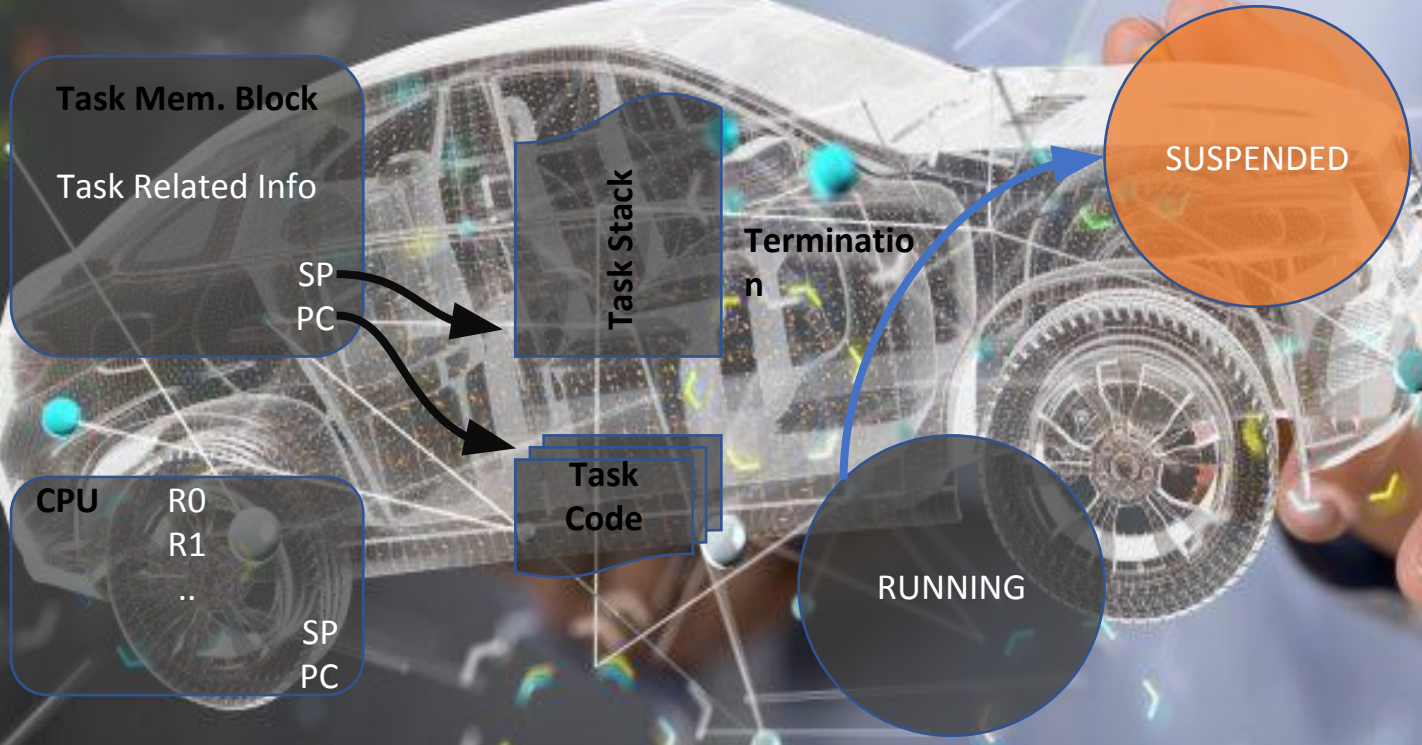

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Conformance Classes

- 4 conformance classes to satisfy different requirements
- The conformance class is determined based on the following:
  - Multiple activation request of task
  - Task types
  - Number of tasks per priority level

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Conformance Classes

ECC 1:

- **Basic / extended tasks are supported**
- **One task per priority Level**
- **No multiple activation**

	Basic task only	Basic& extended task
One Task/Priority No multiple activation	BCC 1	ECC 1
Many Task/Priority Multiple activation	BCC 2	ECC 2

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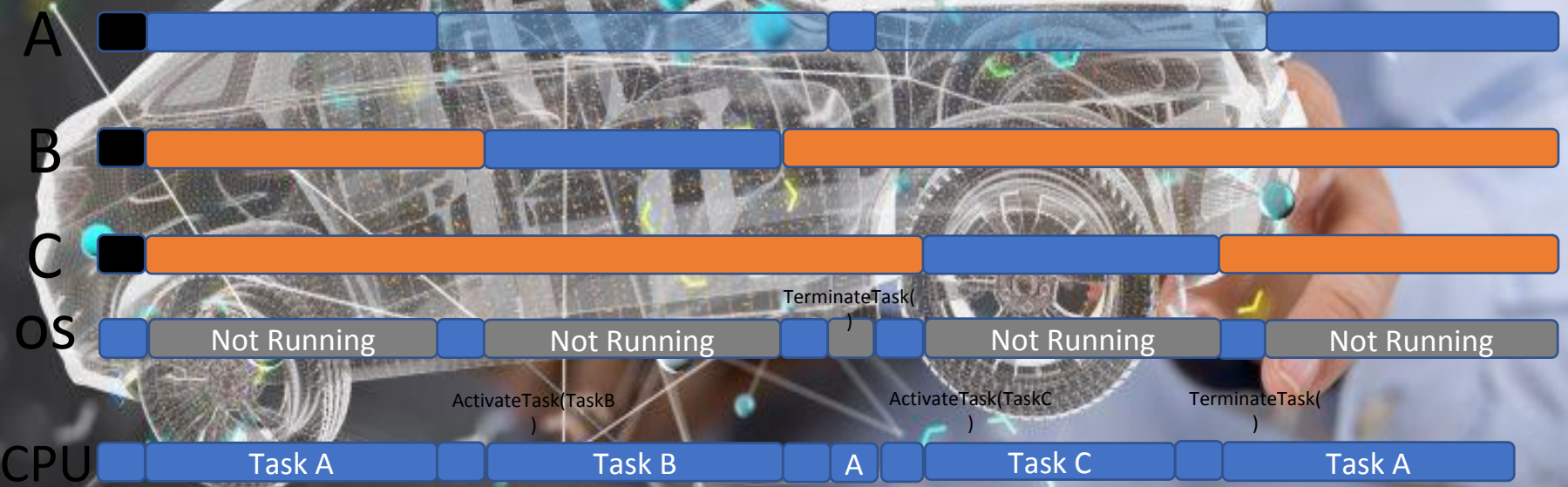
Task Management Ex1



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Task Management Ex1

- Oil description understand
- Code understanding
- Run/debug

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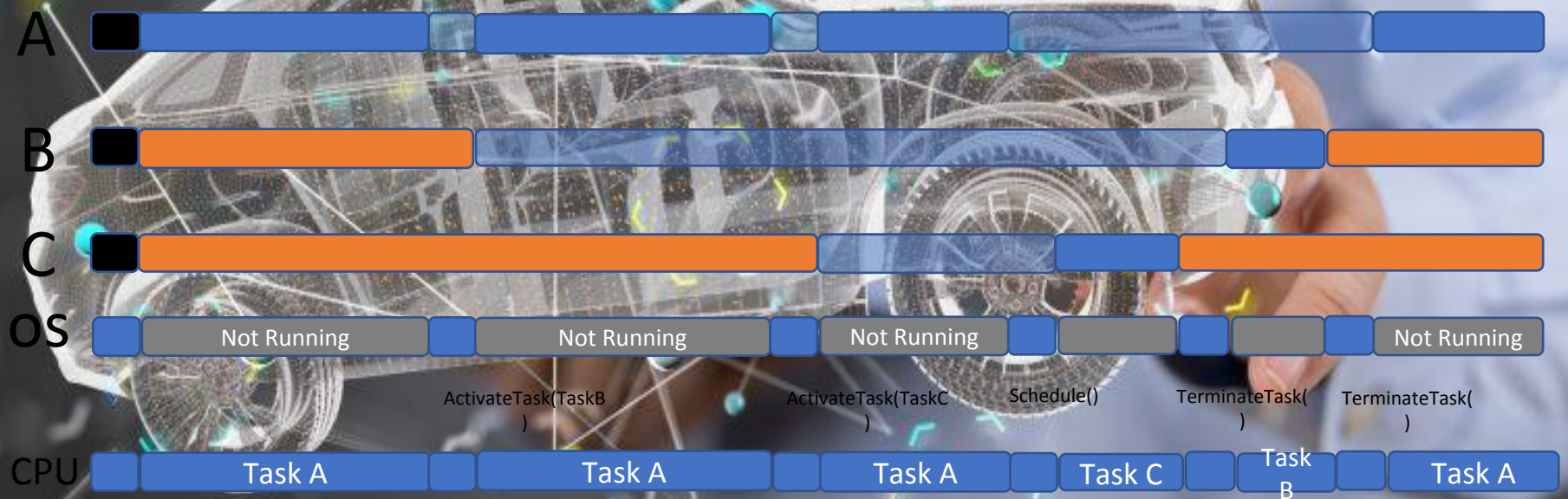
Task Management Ex2

Preemptible /non preemptible Task : OSEK provides “preemptability” as a task attribute



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Task Management Ex2

Oil description understand

Code understanding

Run/debug

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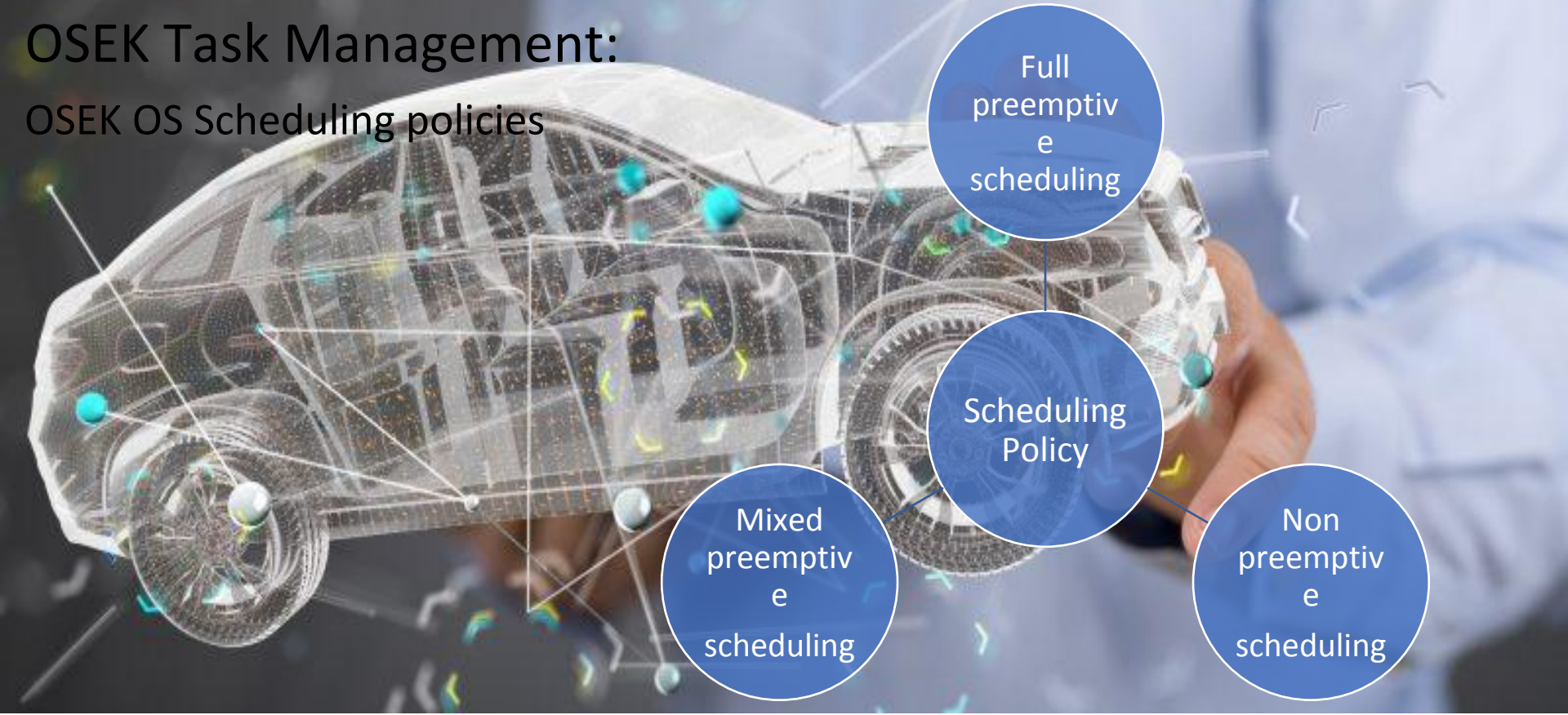
OSEK Task Management:

OSEK OS Scheduling policies



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OSEK Task Management:

Full preemptive scheduling

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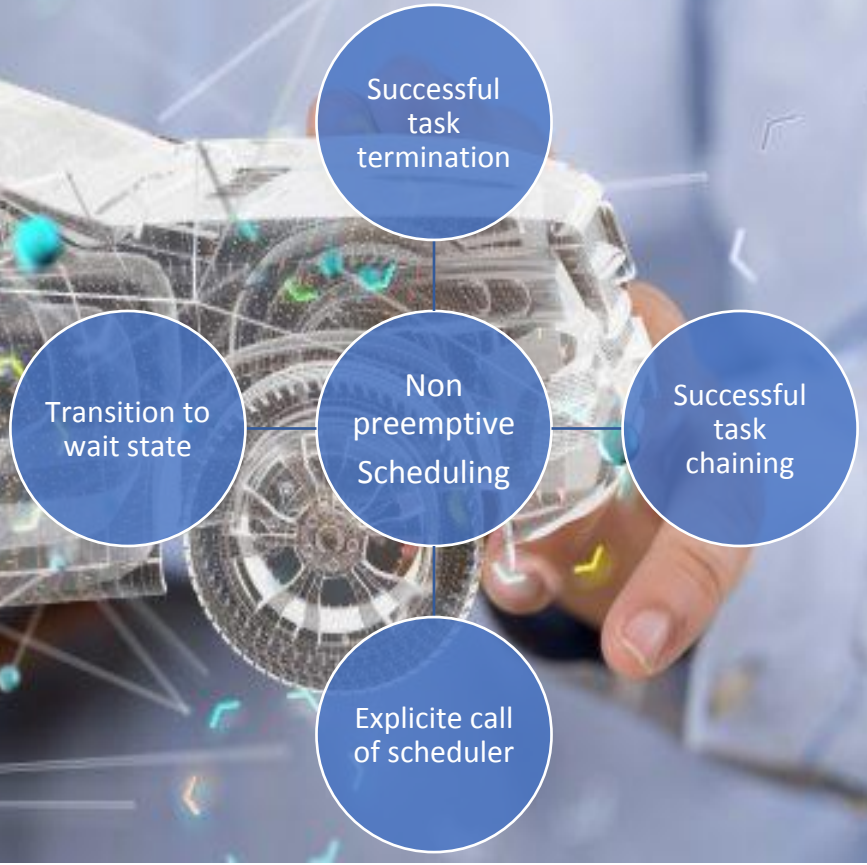
OSEK Task Management:

Non preemptive scheduling



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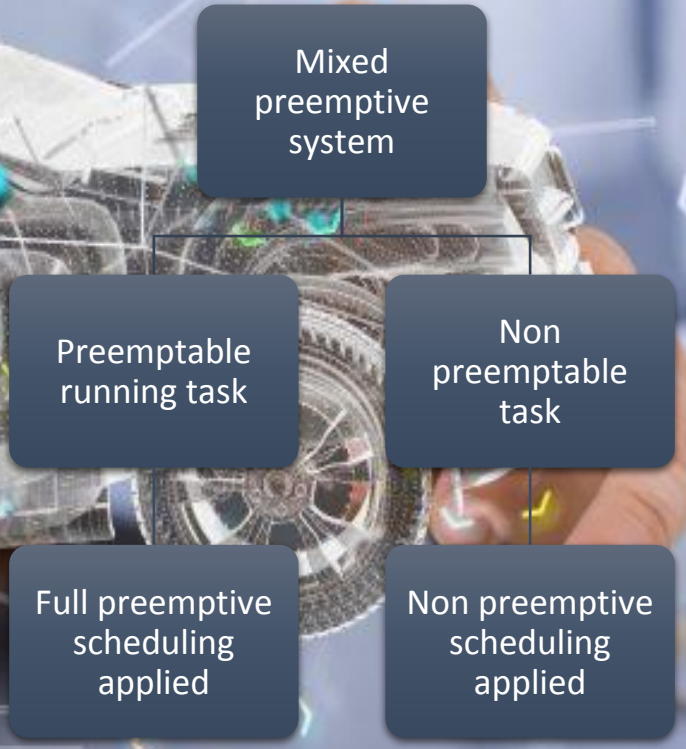
OSEK Task Management:

Mixed preemptive scheduling



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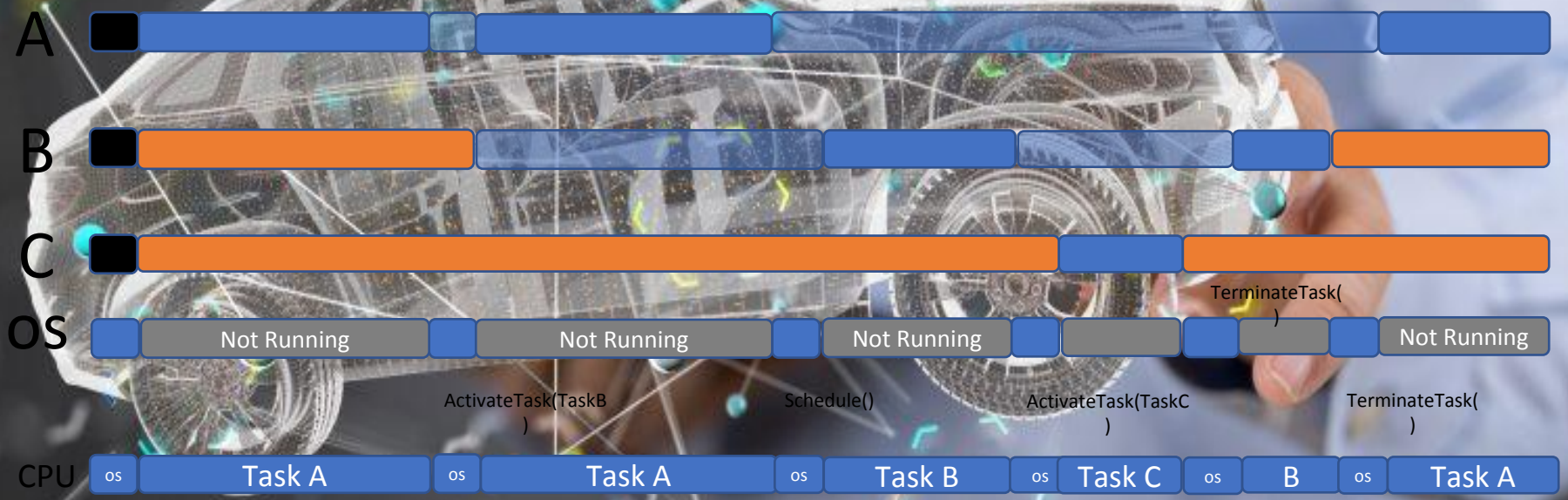
Task Management Ex3



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Task Management Ex3

Oil description understand

Code understanding

Run/debug

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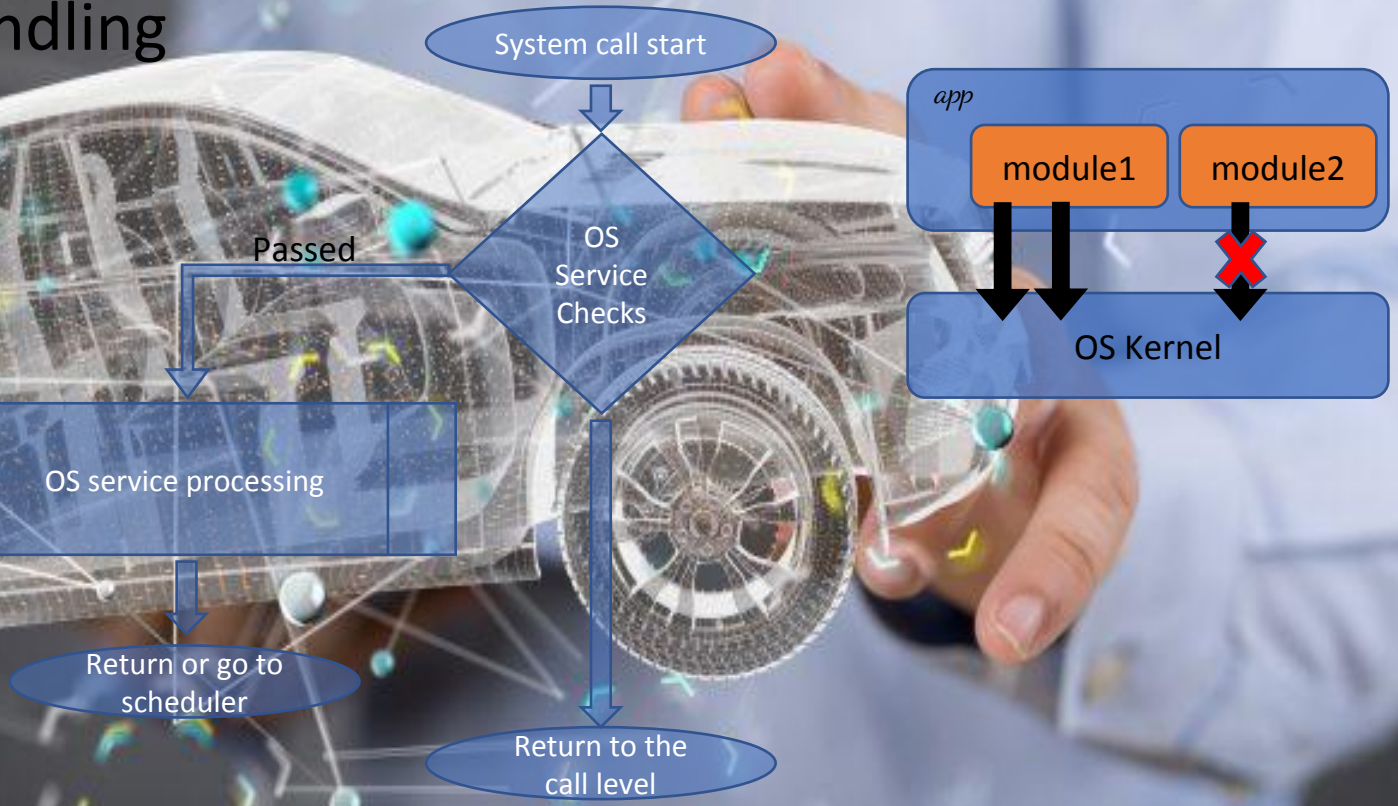
OSEK Error Handling



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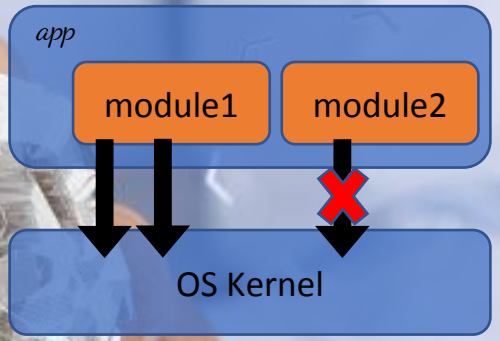
OSEK Error Handling

```
OS SOSEK {
        STATUS = EXTENDED;
            ...
            ..
```



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OSEK Task Management:

Task management services:

StatusType ActivateTask(TaskType Task)

- E_OS_LIMIT
- E_OS_ID
- E_OK

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OSEK Task Management:

Task management services:

StatusType TerminateTask(void)

E_OS_RESOURCE

E_OS_CALLLEVEL

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OSEK Task Management:

Task management services:

- Task can only terminate itself
- Task should terminate itself at the end of its code
- Ending the task without a call to TerminateTask or ChainTask **is not allowed**

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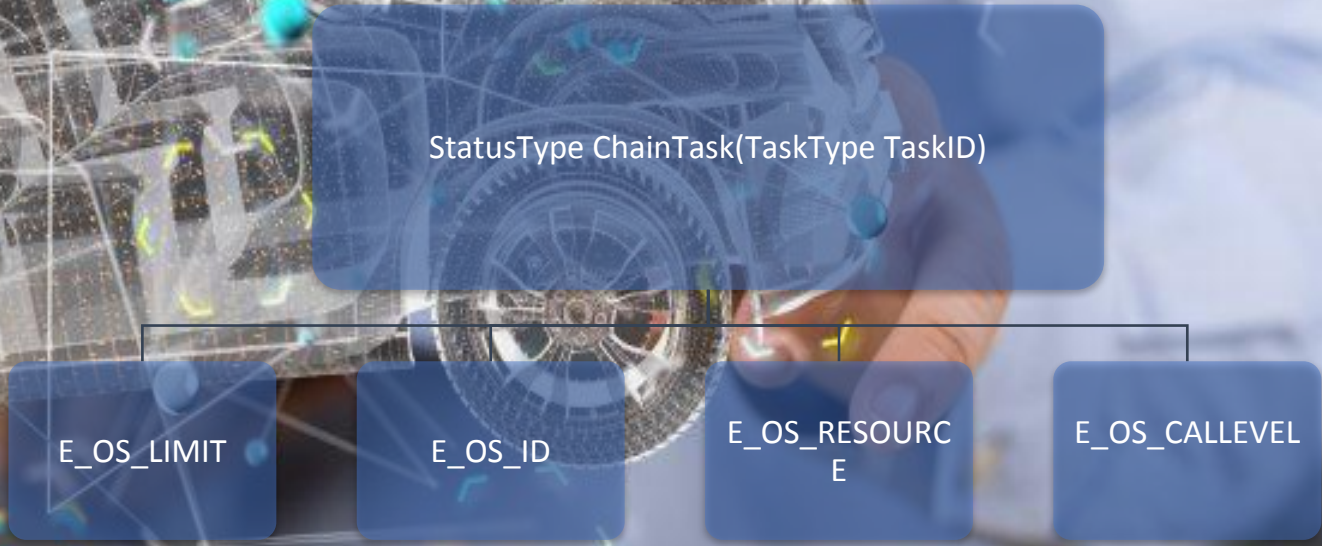
OSEK Task Management:

Task management services:



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OSEK Task Management:

Task management services:

StatusType Schedule(void)

- E_OS_CALLEVEL
- E_OK
- E_OS_RESOURCE

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OSEK Task Management:

Task management services:

- Checks for the highest priority ready task
- The system return to the caller only when ALL higher priority tasks are done
- Schedule() service has no effect on the preemptable tasks

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OSEK Task Management:

Task management services:

- StatusType GetTaskID(TaskRefType TaskID)
- StatusType GetTaskState(TaskType TaskID, TaskStateRefType State)
- DeclareTask(TaskIdentifier)
- TASK(TaskID)

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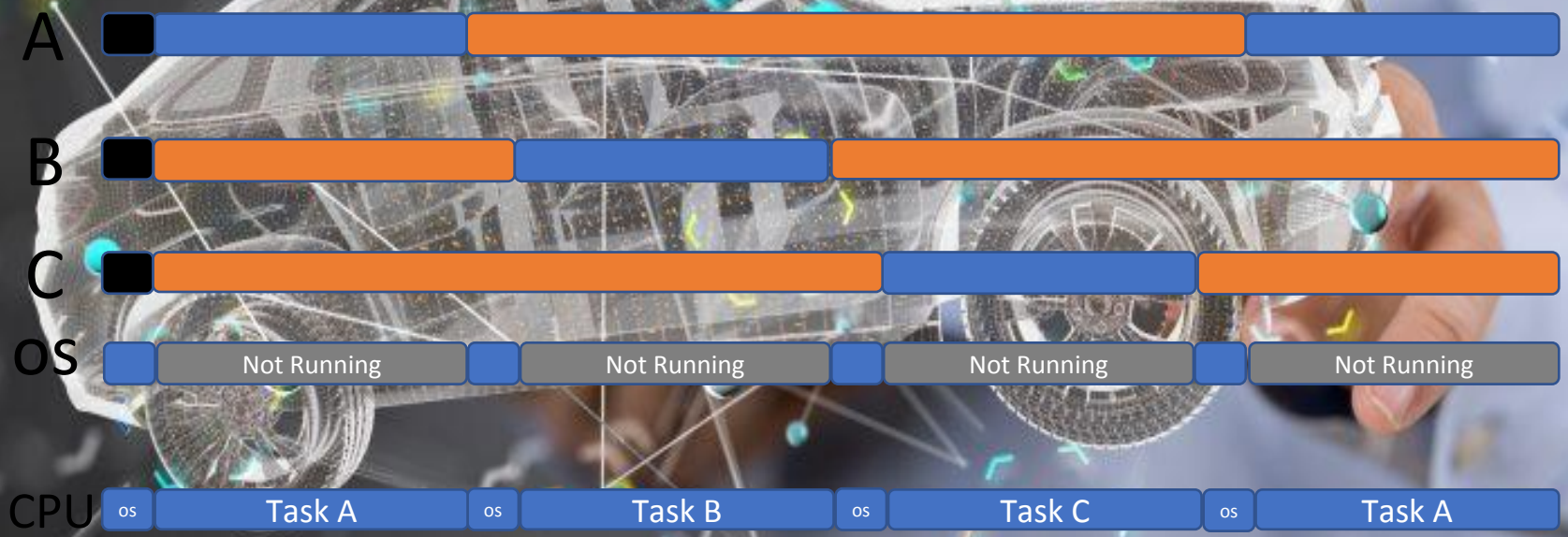
Task Management Ex4



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Task Management Ex4

Oil description understand

Code understanding

Run/debug

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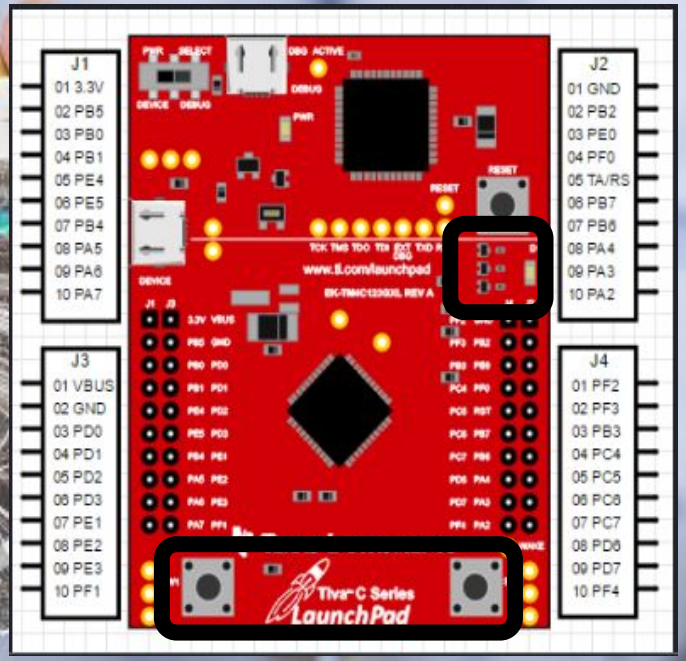
Task Management Ex5

LED simple state machine:

- Input: 2 onboard switches
- Output: 3 LEDs
- Possible state: 4 States



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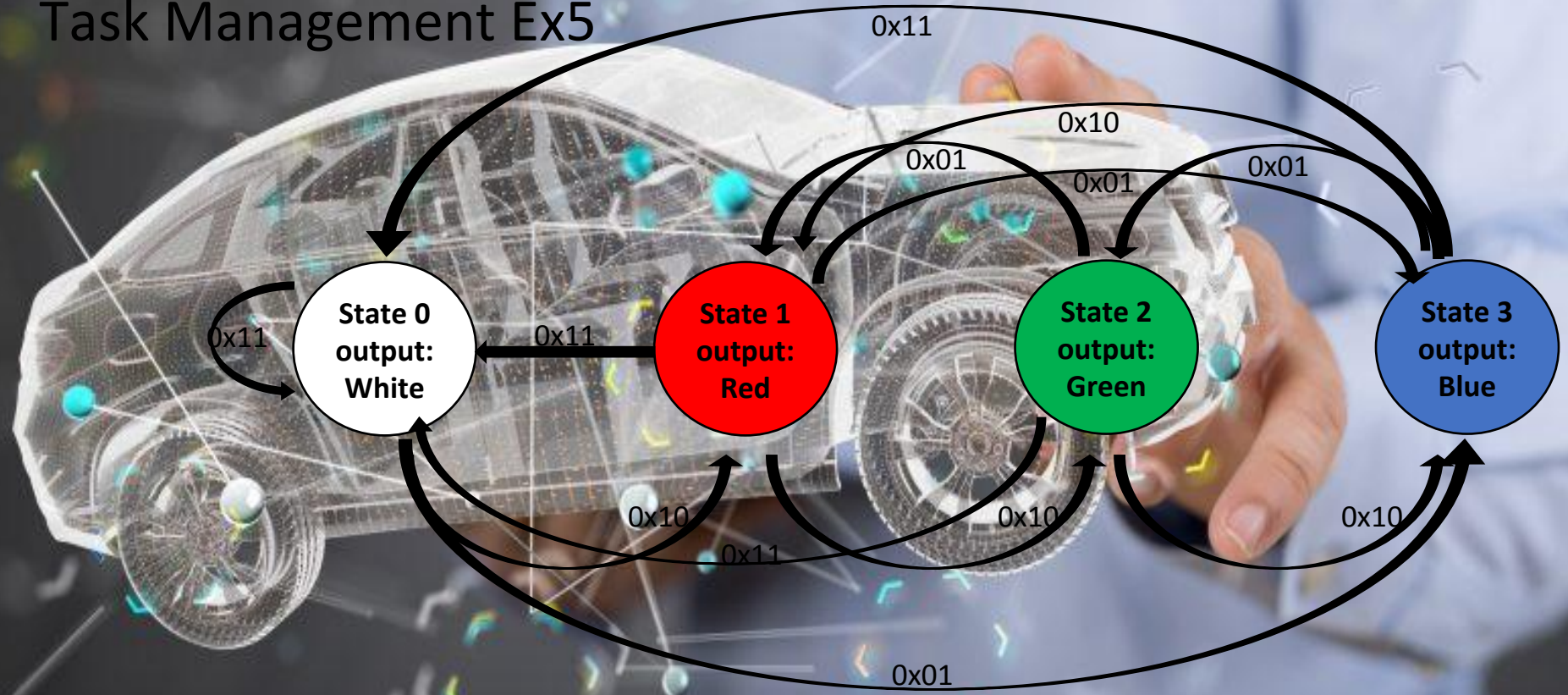
Task Management Ex5



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Task Management Ex5

SW 1	Not Pressed	Pressed	Pressed	Pressed	Not Pressed	Not Pressed	Not Pressed	Not Pressed	Not Pressed	Not Pressed
SW 2	Not Pressed	Not Pressed	Not Pressed	Not Pressed	Not Pressed	Pressed	Pressed	Pressed	Pressed	Not Pressed
State										

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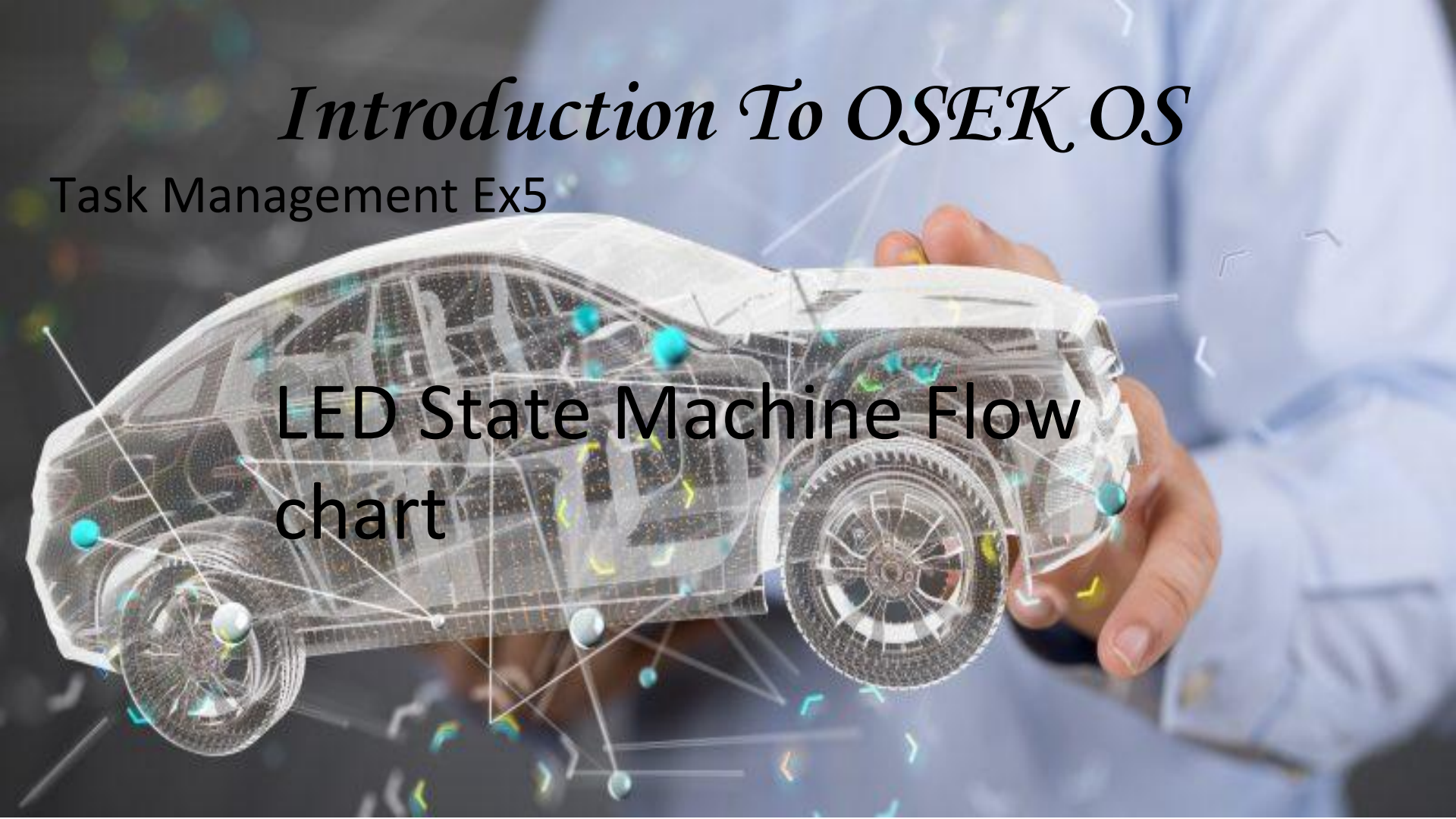
Task Management Ex5



LED State Machine Flow chart

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Task Management Ex5

Oil description understand

Code understanding

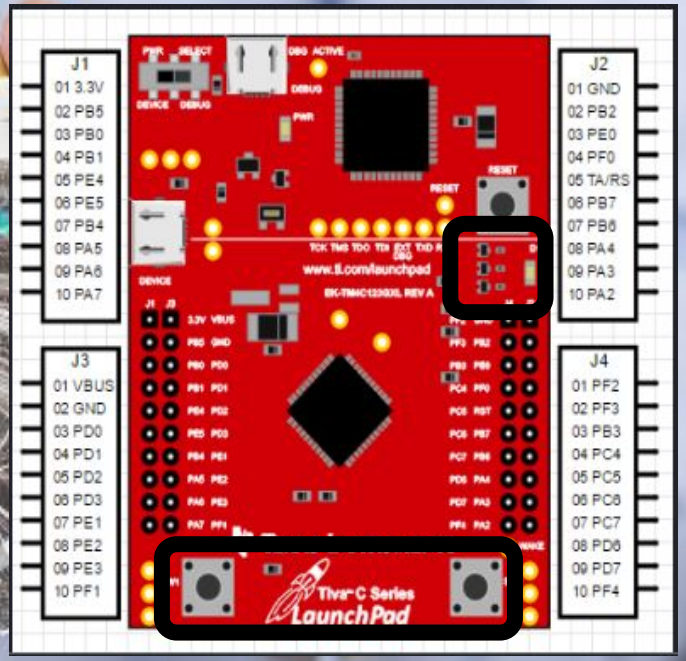
Run/debug

Introduction To OSEK OS

Task Management Assignment

LED sequence state machine:

- Input: 2 onboard switches
- Output: 3 LEDs
- Four Tasks shall be implemented:
  - Task_Init
  - Task_BasicState
  - Task_RGB
  - Task_BGR



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Task Management Ex5

LED Sequence State Machine Flow chart

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Task Management Assignment 2

High level problem statement

- Alarm should be triggered if at least one of the doors is not closed
- Alarm should not be triggered if both of the doors are closed

Assumptions

- The system is composed of 2 doors and 1 alarm
- No timing requirements

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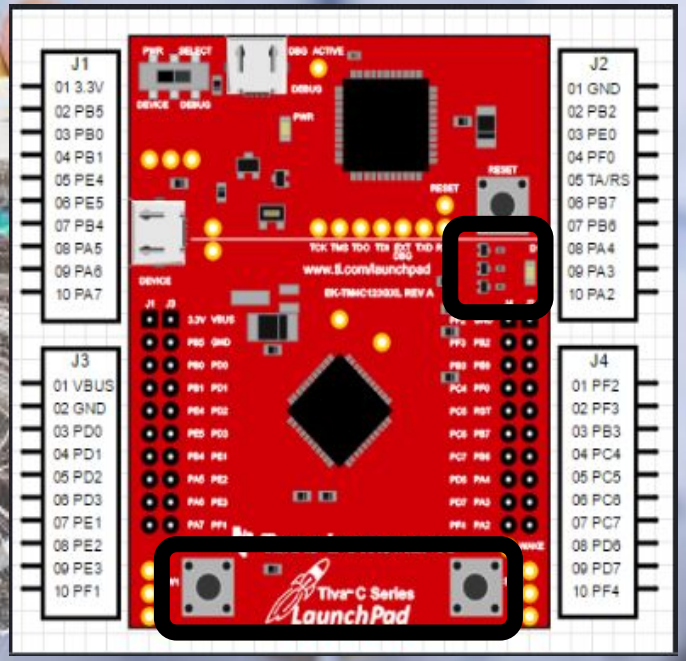
Task Management Assignment 2

Simplify the problem

- We will assume the sensors and alarm are on the same ECU
- We will use the on board switches to represent the door sensors
- We will use the on board red LED to represent the alarm activation



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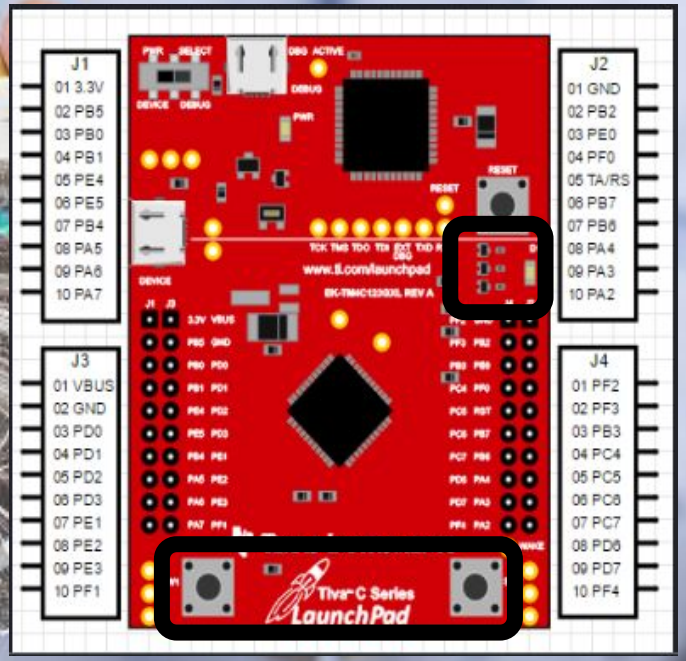
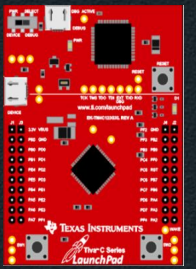
Task Management Assignment 2

- Write your own oil description file
- Use a different threads to achieve the whole functionality
- Try to re-use from the previous examples(oil/code.. etc.).



Intro to OSEK RTOS I

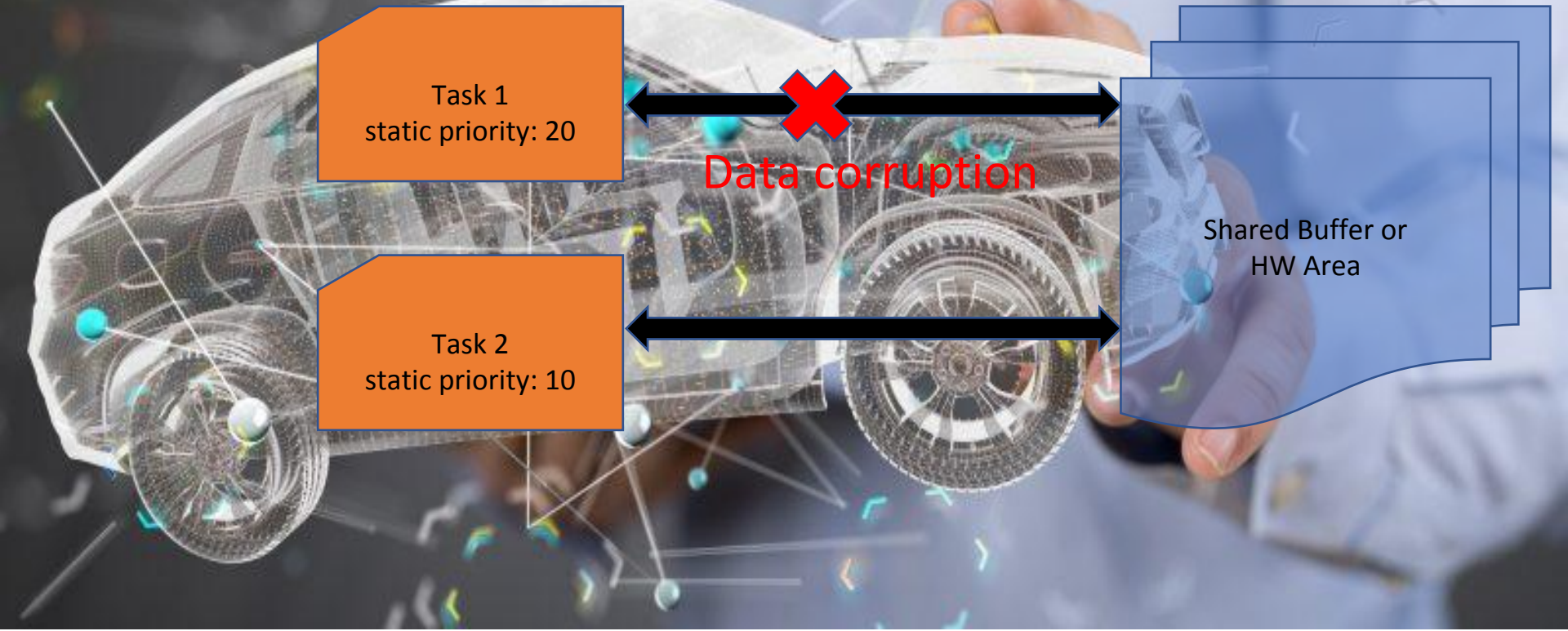
```
string sInput;
int iLength, iN;
double dblTemp;
bool again = true;

while (again) {
    iN = -1;
    again = false;
    getline(cin, sInput);
    system("cls");
    stringstream(sInput) >> dblTemp;
    iLength = sInput.length();
    if (iLength < 4) {
        again = true;
        continue;
    } else if (sInput[iLength - 3] != '.') {
        again = true;
        continue;
    } while (++iN < iLength) {
        if (isdigit(sInput[iN])) {
            continue;
        } else if (iN == (iLength - 3) ) {
            continue;
```



OSEK Generator

Introduction To OSEK OS

Multithreading and concurrent access



Introduction To OSEK OS

Multithreading And Racing

0x20000020	00	00	00	0B

R0	0x0B
R1	0x20000020

```
; …
LDR  R0 , [R1]
ADD  R0, R0, #1
STR  R0, [R1]
; …
```

0x20000020	00	00	00	0B

RMW_Task CPU Context
static priority: 10

CntInitTask CPU context
static priority: 20

```
uint32_t g_u32_Counter = 0U;
TASK(RMW_Task )
{
    // …
    // increments by 1
    g_u32_Counter+=1U;
    //…
}
TASK(CntInitTask)
{
    // …
    if(/*some condition*/)
    {
      /* re init the counter */
      g_u32_Counter = 0U;
    }
    //…
}
```

Introduction To OSEK OS

Multithreading And Racing

0x20000020	00	00	00	F1

R0	0xF1
R1	0x20000020

```
; …
LDRB  R0 , [R1]
ORR   R0, R0, #1
STRB  R0, [R1]
; …
```

0x20000020	00	00	00	F1

Bit0_Task CPU Context
static priority: 10

Bit1_Task CPU context
static priority: 20

```
uint8_t EnableMask= 0x00U;
TASK(Bit0_Task )
{
    // …
    // EnableMask is 0xF0
    //Enable bit 0
    EnableMask |= 0x01
    //…
}

TASK(Bit1_Task)
{
    // …
    if(/*some condition*/)
    {
      //Enable bit 1
    EnableMask |= 0x02;
    }
    //…
}
```

Correct EnableMask	***0xF3***	***0b1111 0011***
Actual EnableMask	***0xF1***	***0b1111 0001***

Introduction To OSEK OS

Multithreading And Data Inconsistency

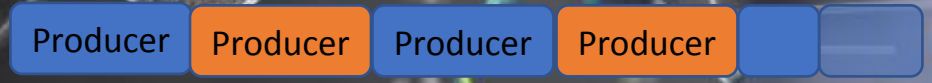
Producer Task
static priority: 10
Period: 10 ms

Time Stamp	99929.2123
ID	Client _0x01
Data[0]	0x3A
Data[1]	0xB0
…	…
Data[n]	…

Consumer Task
static priority: 15

- Time stamp: 9960.323
- ID: 0x04
- Data[0..n] = 0x2F, 0x43, 0x8E…etc.

- Time stamp: 9970.397
- ID: 0x02
- Data[0..n] = 0x2F, 0x43, 0x8E…etc.



Introduction To OSEK OS

Resource Example

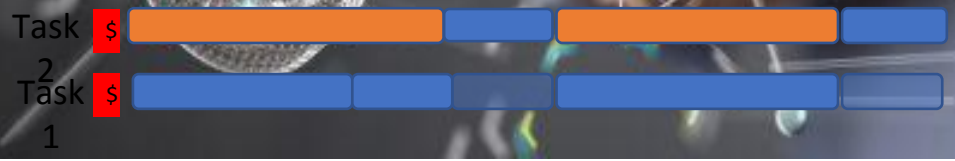
- Oil description understand
- Code understanding
- Run/debug

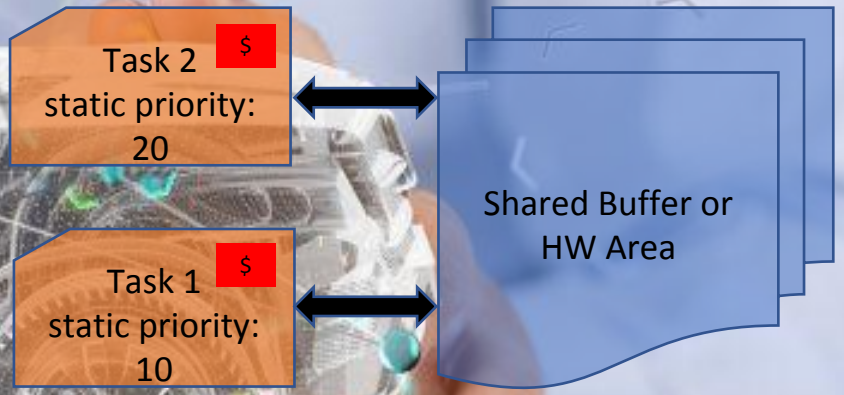
Introduction To OSEK OS

Semaphore, Mutex or Resource

```
uint32_t g_u32_Counter = 0U;
TASK(Task1)
{
        // ...
        //GetSemaphoreAPI()

        g_u32_Counter+=1U;
        //..
        // Accessing the shared
        // Resource

        //GiveSemaphoreAPI()
}
```

```
TASK(Task2)
{
        // ...
        //GetSemaphoreAPI()
        //..
        g_u32_Counter = 0U;
        //..
        // Accessing the shared
        // Resource

        //GiveSemaphoreAPI()
}
```





Only one task at a time

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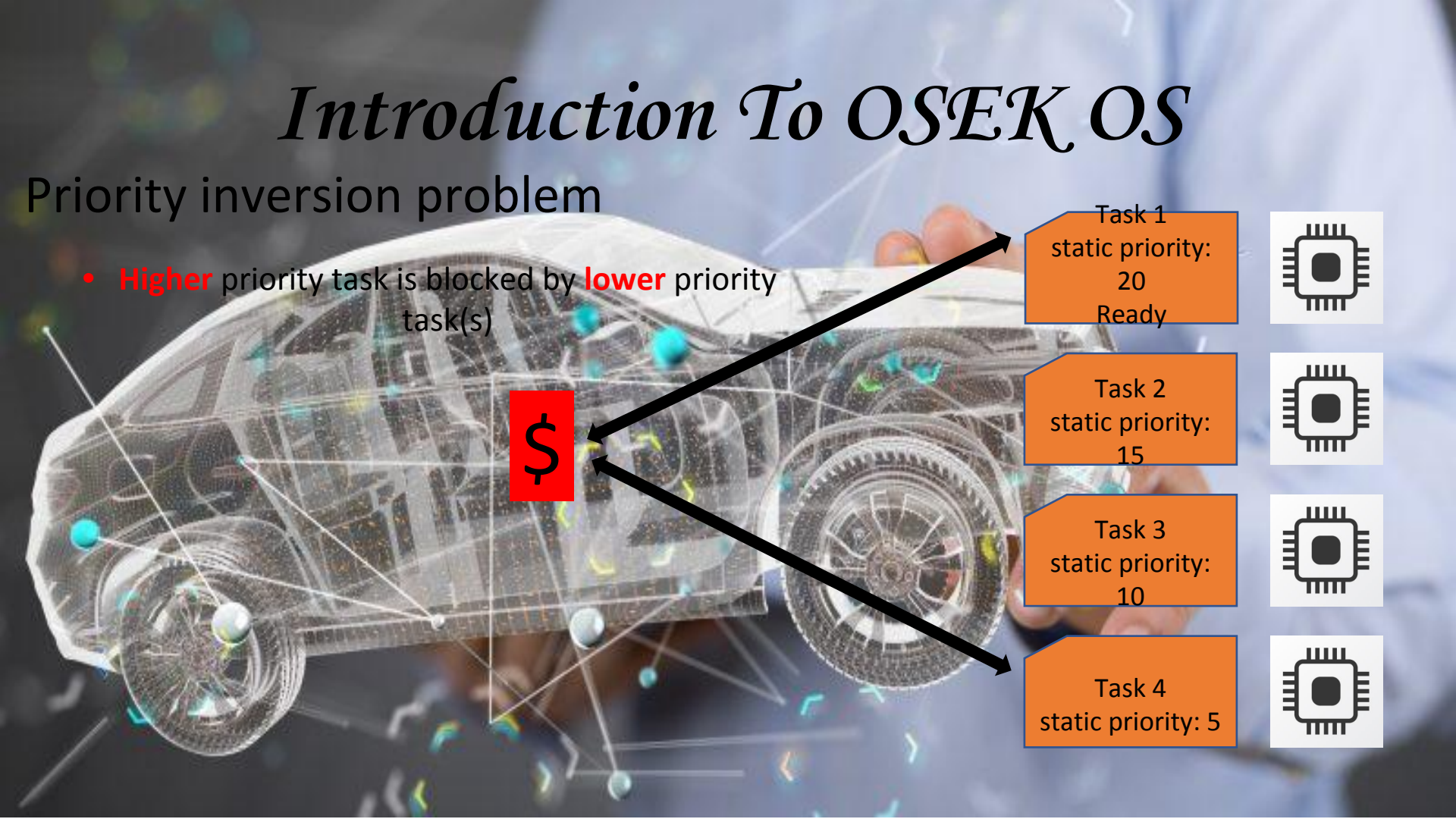
Priority inversion problem

- **Higher** priority task is blocked by **lower** priority task(s)



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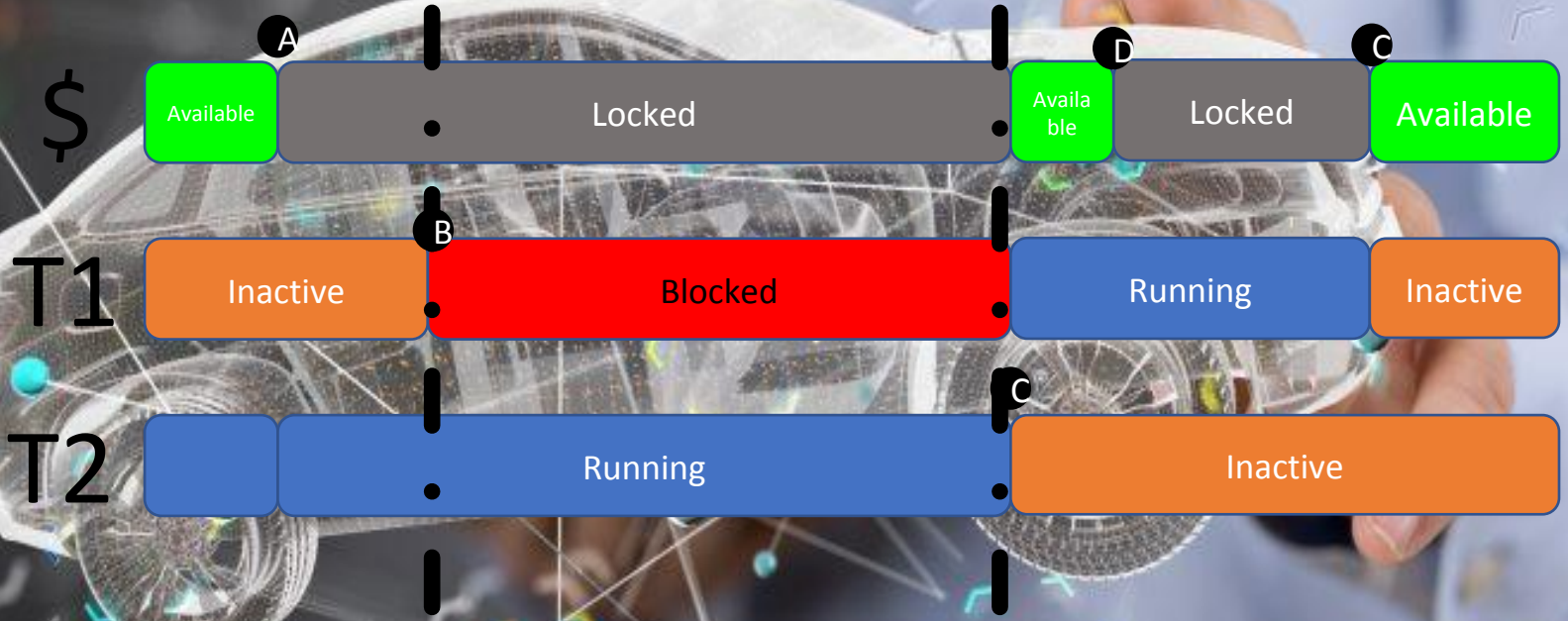
Priority inversion problem



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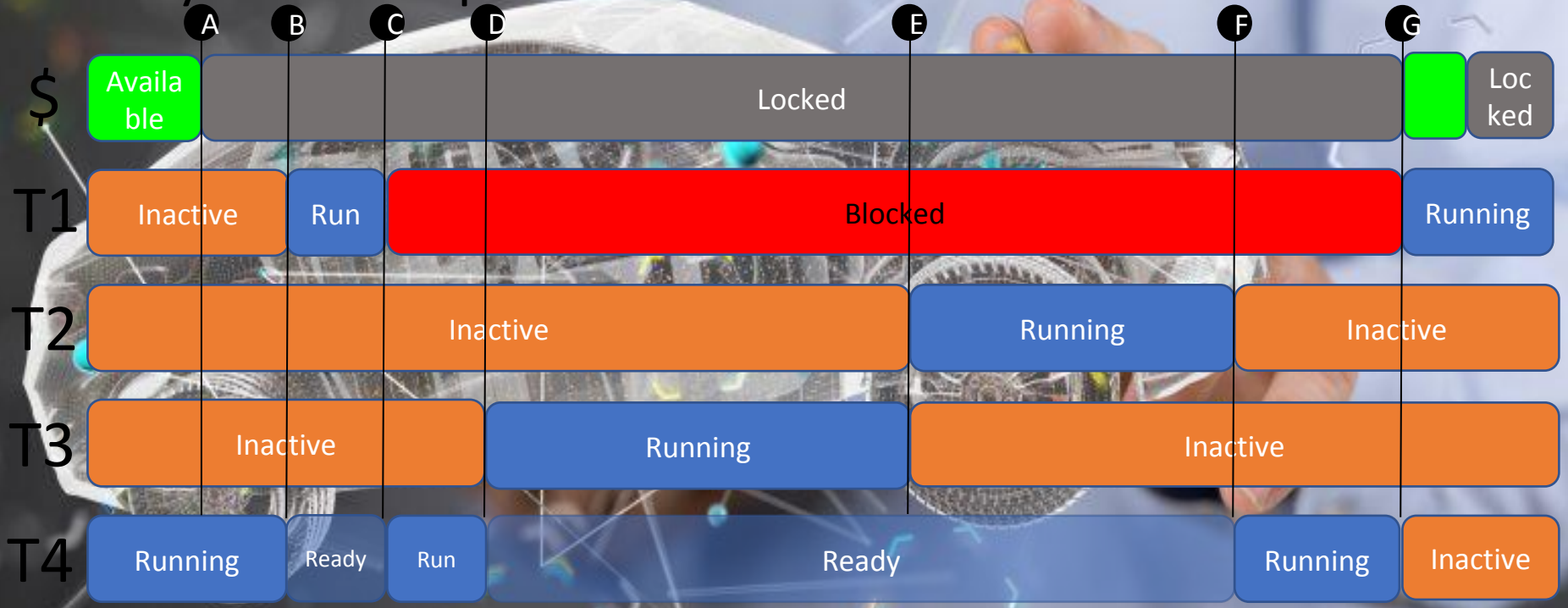
Priority inversion problem



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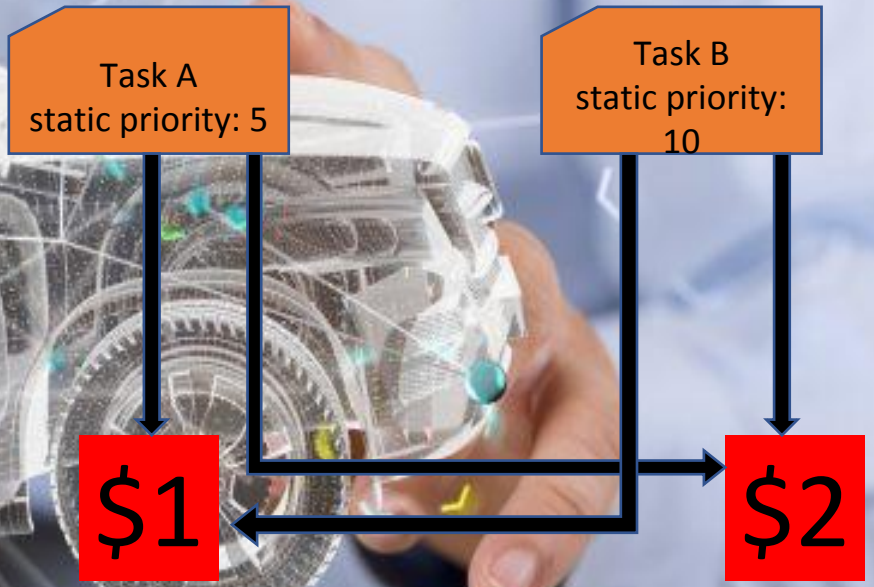
Deadlock problem

- **Task stopping & System freeze**
- **Impossible conditions**



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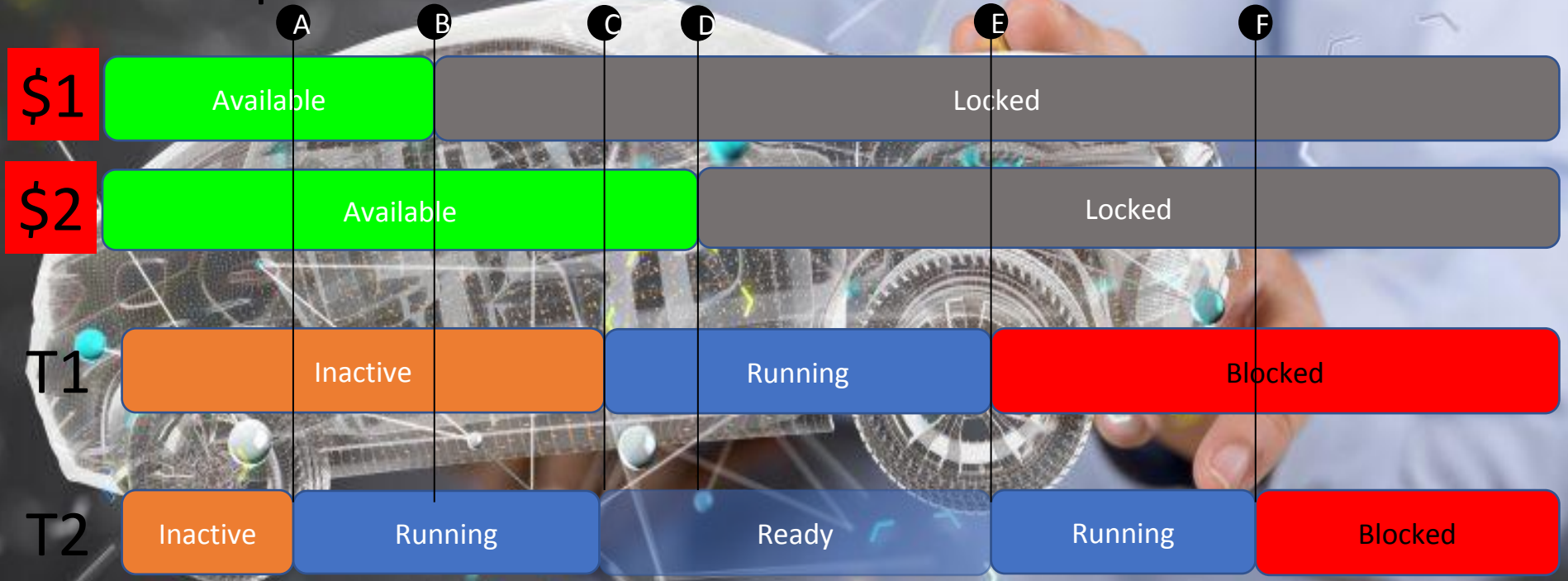
Deadlock problem

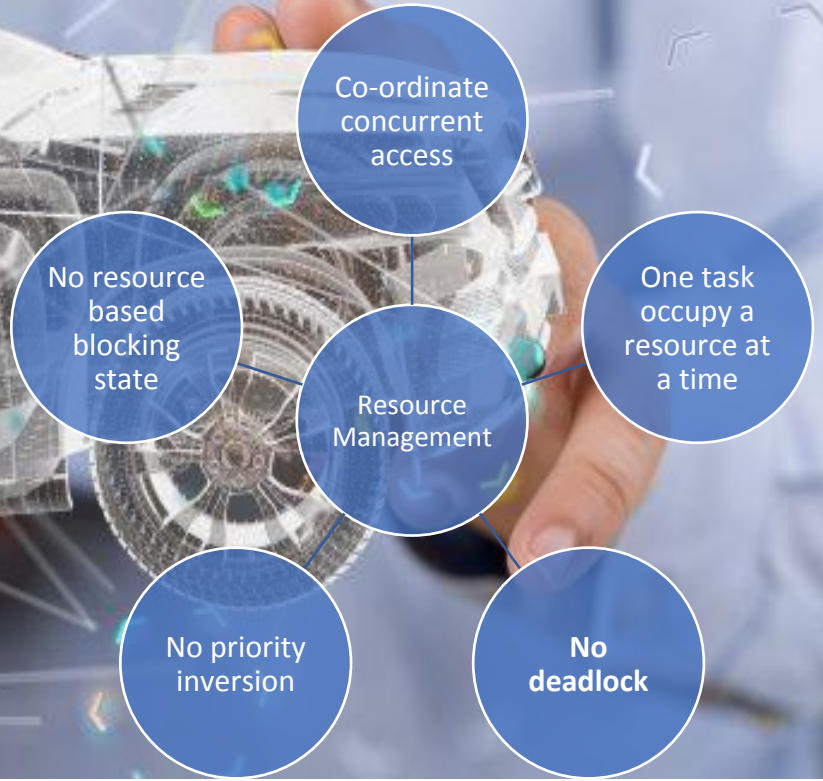


Introduction To OSEK OS

OSEK resource management

Priority Ceiling Pattern:

To avoid deadlocks and priority inversion



Introduction To OSEK OS

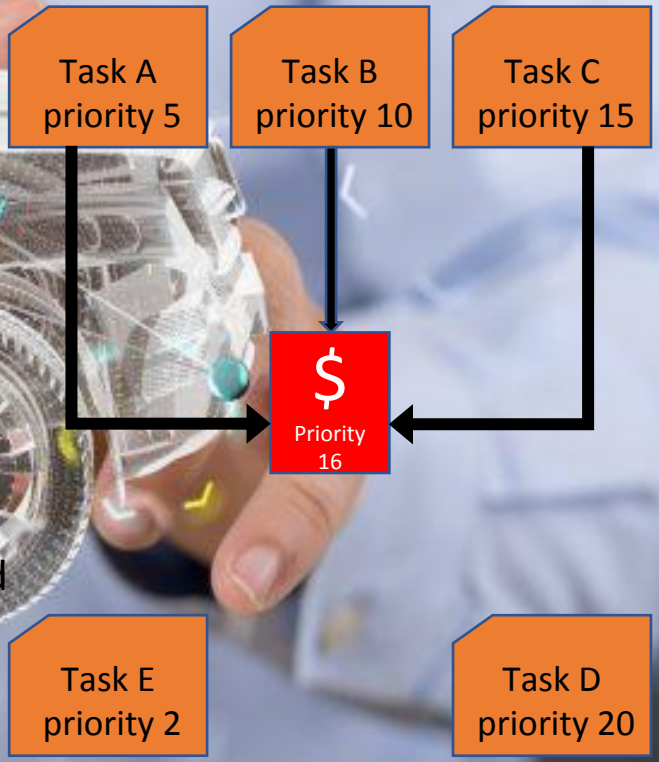
OSEK priority ceiling protocol

- ***At generation/compilation time***

1. Every $ □ Priority level (the ceiling priority)
2. Priority level > max user task priority
3. Priority level < min non user task priority (if higher than the highest user)

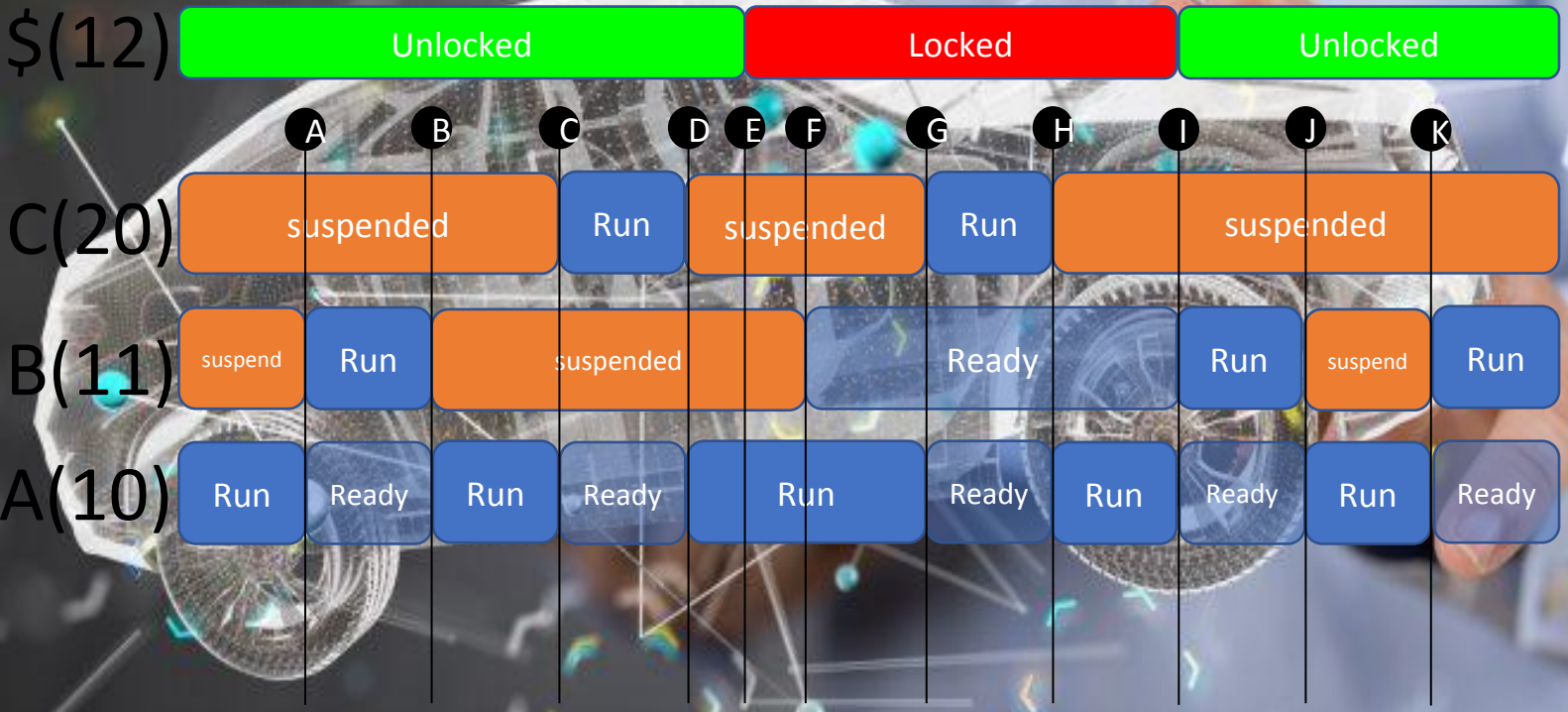
- **Run time behavior**

1. Requiring a resource □ execute at the ceiling priority level
2. Releasing a resource □ back to the nominal priority level
   □ Scheduling point if preemptable thread



Introduction To OSEK OS

Resource Management Example 1



Introduction To OSEK OS

Resource Example

- Oil description understand
- Code understanding
- Run/debug

Introduction To OSEK OS

OSEK resources APIs

StatusType GetResource (ResourceType <ResID>)

1. Entering the critical section
2. The Ceiling priority will be applied
3. The used error codes:
   1. E_OK
   2. E_OS_ID
   3. E_OS_ACCESS

StatusType ReleaseResource (ResourceType <ResID>)

1. Leave the critical section
2. The static priority will be applied
3. The used error codes:
   1. E_OK
   2. E_OS_ID
   3. E_OS_NOFUNC
   4. E_OS_ACCESS

Introduction To OSEK OS

OSEK resources APIs

Usage restriction while holding resource

- *TerminateTask -> E_OS_RESOURCE*
- *ChainTask -> E_OS_RESOURCE*
- *Schedule -> E_OS_RESOURCE*
- *WaitEvent -> E_OS_RESOURCE*

Introduction To OSEK OS

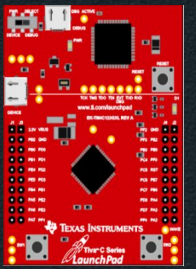
Resource Management Example 2

- Oil description understand
- Code understanding
- Run/debug

Intro to OSEK RTOS I

```
string sInput;
int iLength, iN;
double dblTemp;
bool again = true;

while (again) {
    iN = -1;
    again = false;
    getline(cin, sInput);
    system("cls");
    stringstream(sInput) >> dblTemp;
    iLength = sInput.length();
    if (iLength < 4) {
        again = true;
        continue;
    } else if (sInput[iLength - 3] != '.') {
        again = true;
        continue;
    } while (++iN < iLength) {
        if (isdigit(sInput[iN])) {
            continue;
        } else if (iN == (iLength - 3) ) {
            continue;
```



OSEK Generator