Java application platforms for design-to-cost embedded systems

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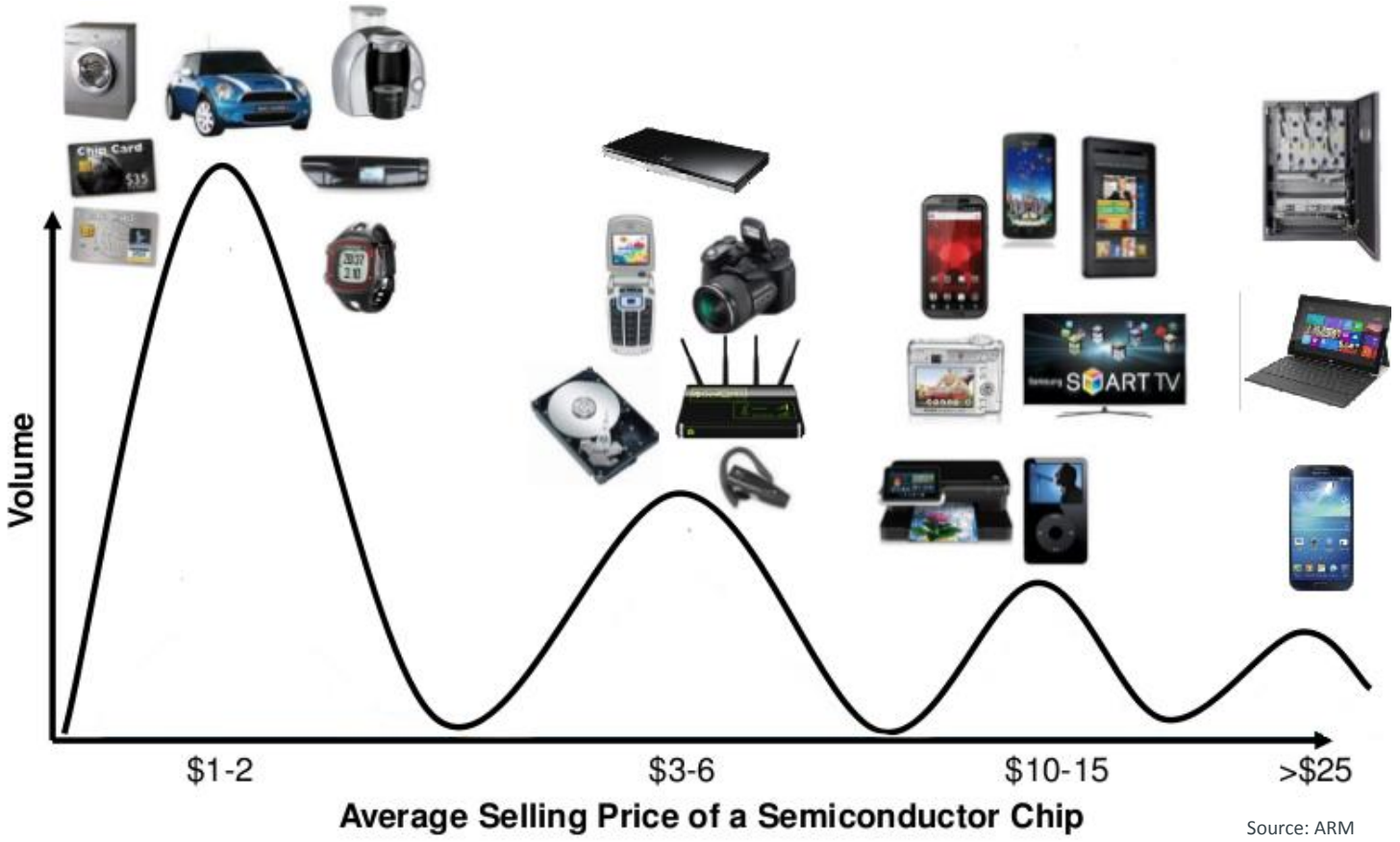
Embedded Processing Market Share

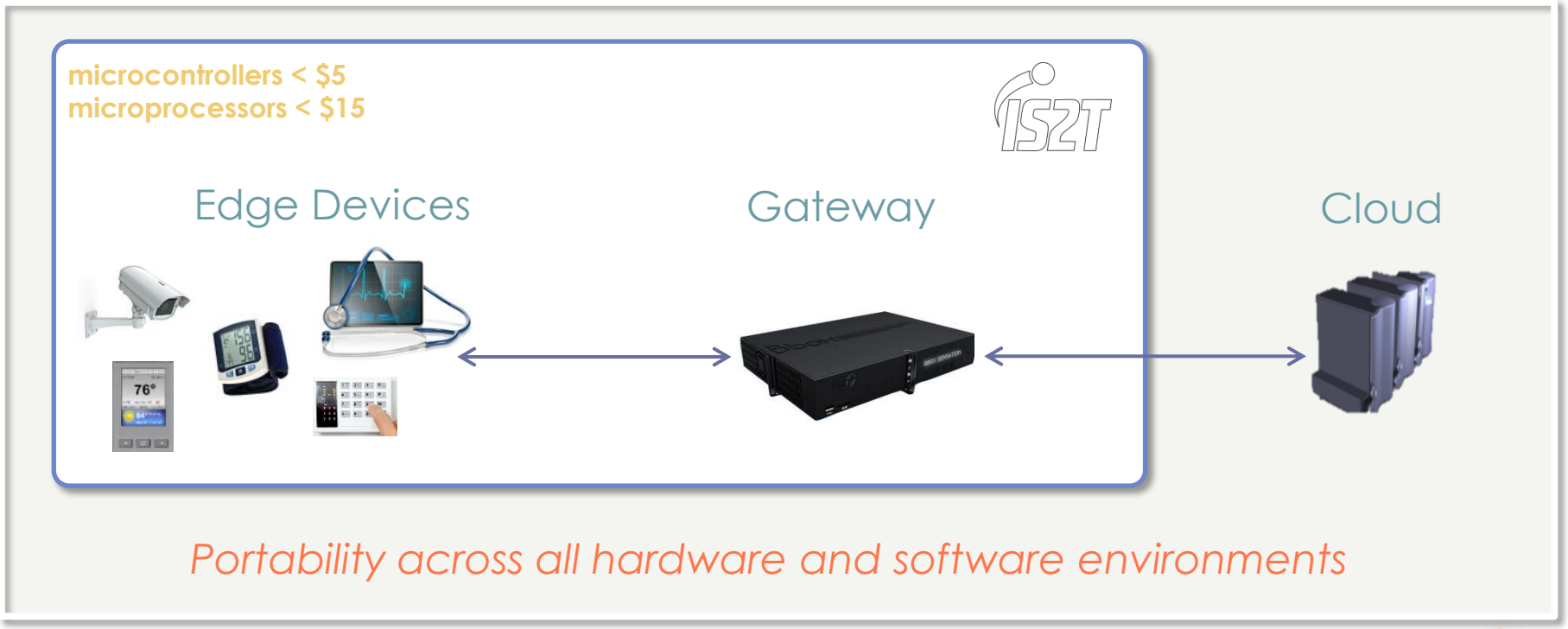


Source: ARM

IS2T - Solutions for Embedded Innovations

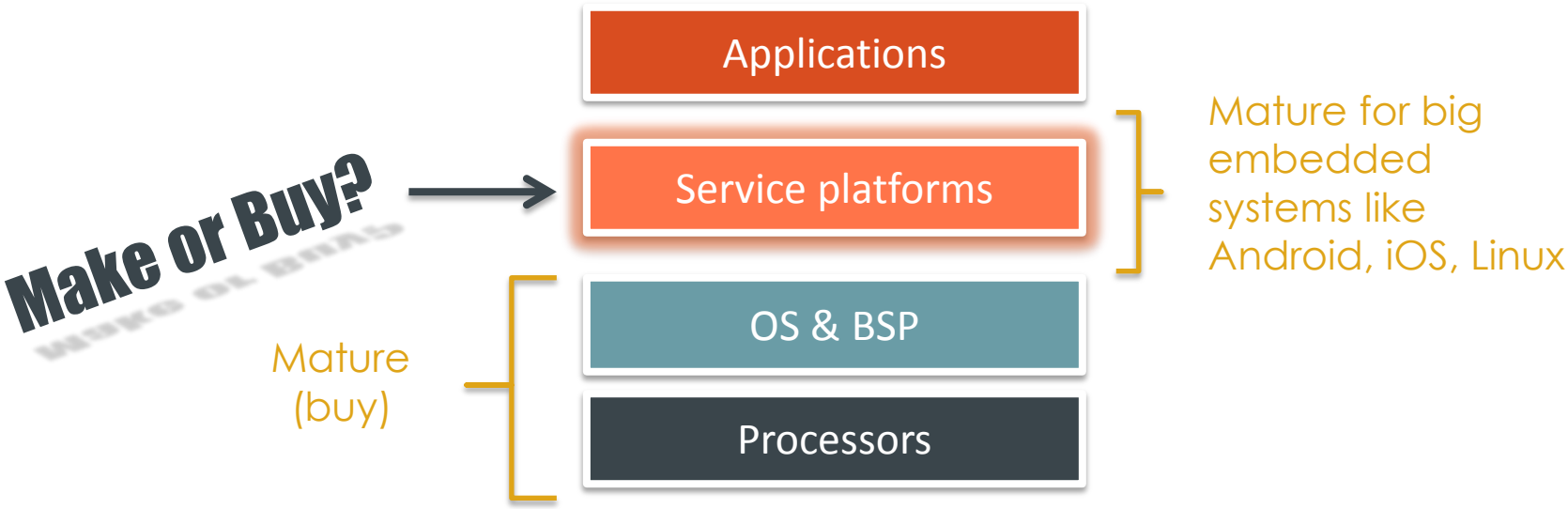
Develop software applications and leverage innovations

at low Total Cost of Ownership.

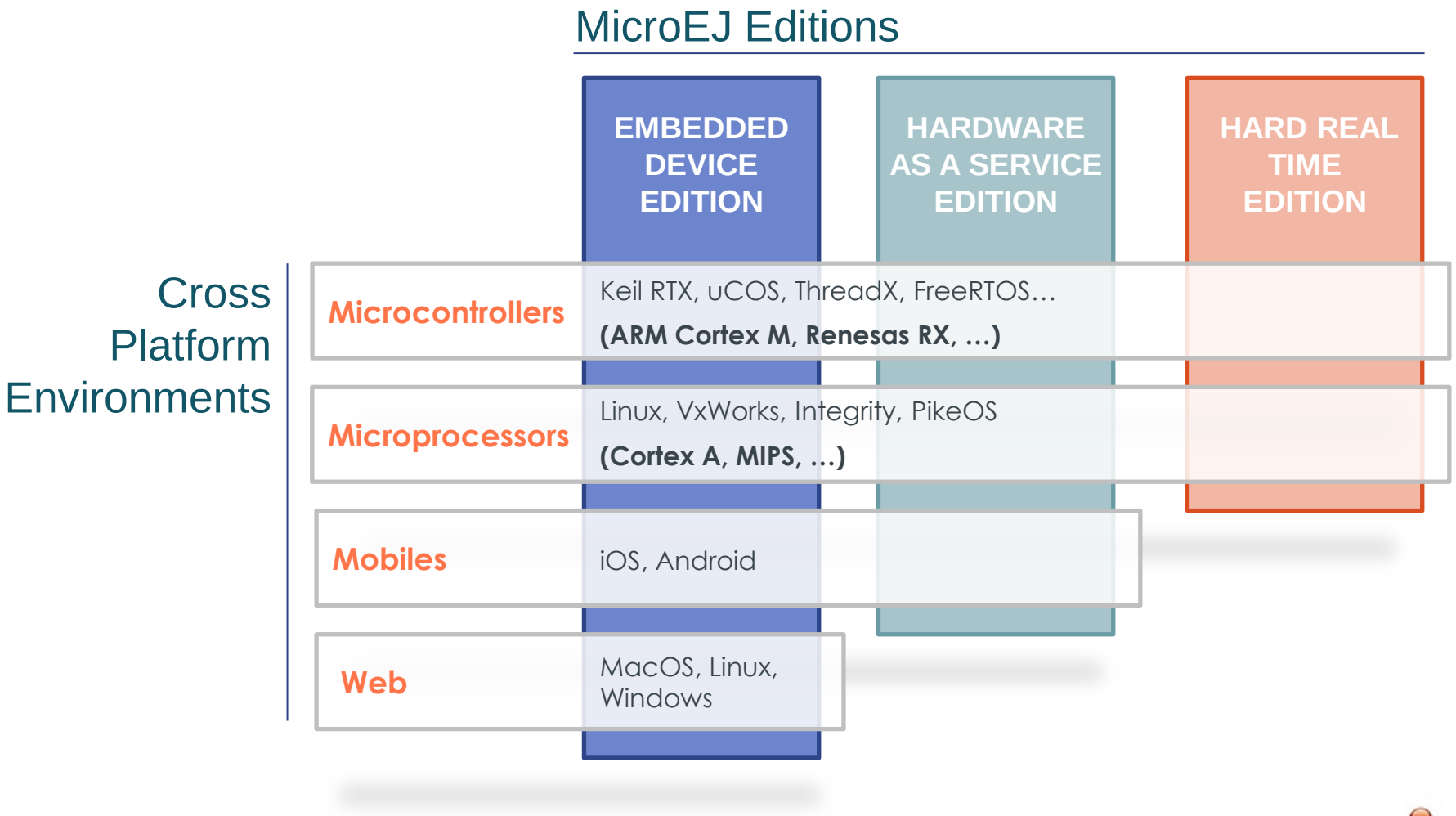


Embedded Market Maturity

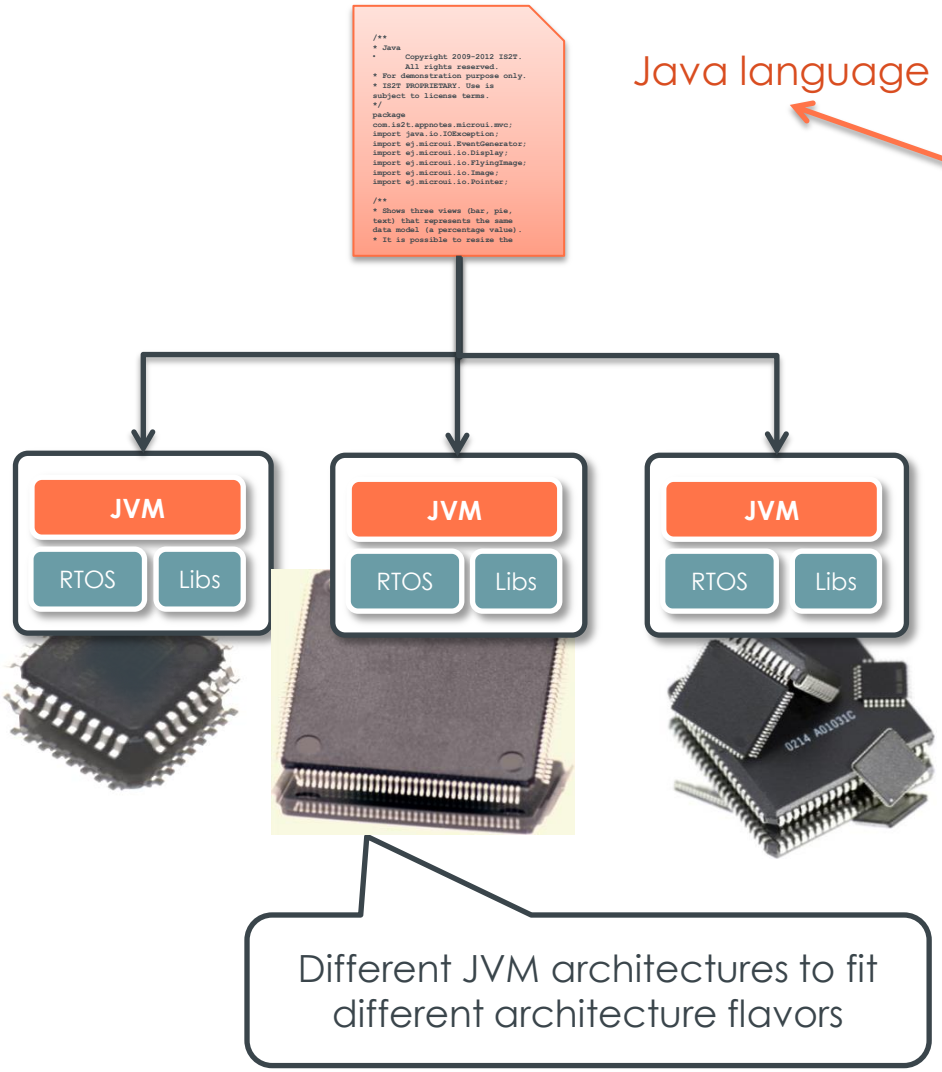
- Like servers, workstations and smartphones…
- … cost constrained embedded systems now look at 3rd party "platform" procurement



MicroEJ Platforms



Java Platforms Concept for Embedded systems



Optimized MicroEJ® VMs

32/64-bit CPU

Optimized implementation

32-bit MCU/MPU

Java

- Code quality
- Productivity
- Reliability
- Portability
- Scalability
- Maintainability
- Code density

Java

- High speed execution
- Determinism (HRT)
- Tiny footprint
- Interface C/asm
- Low power, etc.

Embedded Java Platform Example

life.augmented

- STM32F2x (Cortex-M3) – 120MHz
- 16-bit col. QVGA LCD, Touch
- APIs: B-ON, MicroUI, MWT, SNI
- Boot time (reset to `main(String[] args)`): 2ms

Application Memory Requirements

	Flash (ROM)	422KB	RAM	42KB
Java needs	Virtual Machine (runtime & GC)	28KB	Virtual Machine	1KB
	Libraries (graphics, com, float…)	132KB	Native Stack	28KB
	Graphical resources (images)	228KB		
	Application	34KB	Application	13KB

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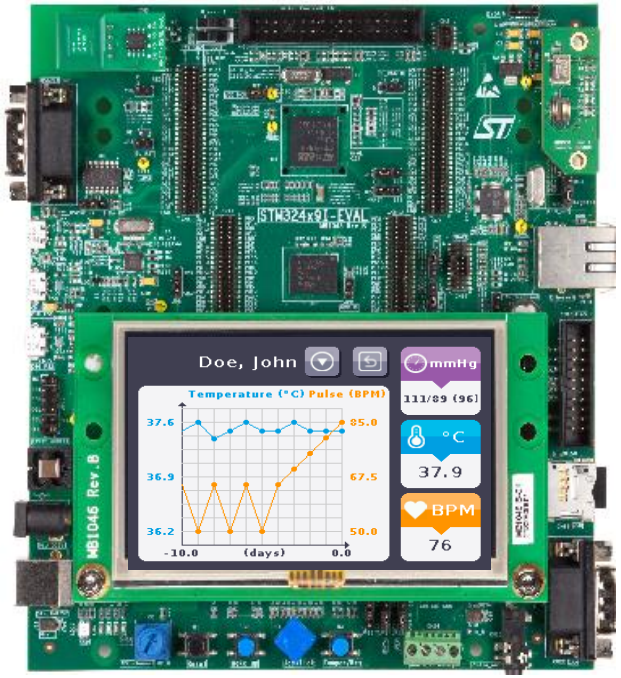
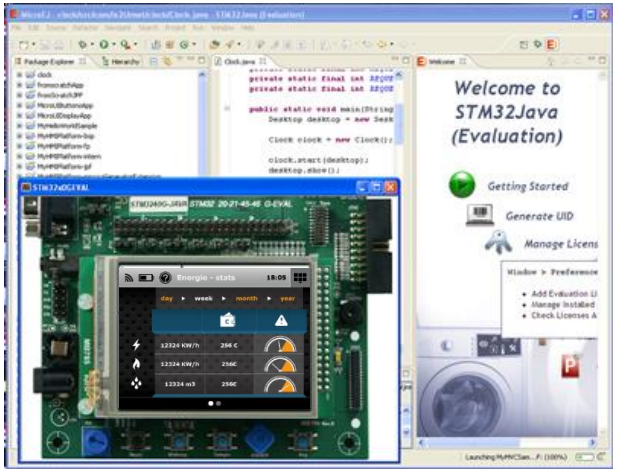
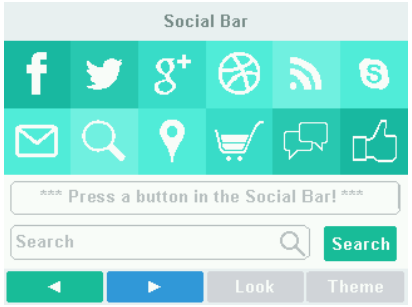
GUI Examples on STM32 MCUs





Eclipse IDE

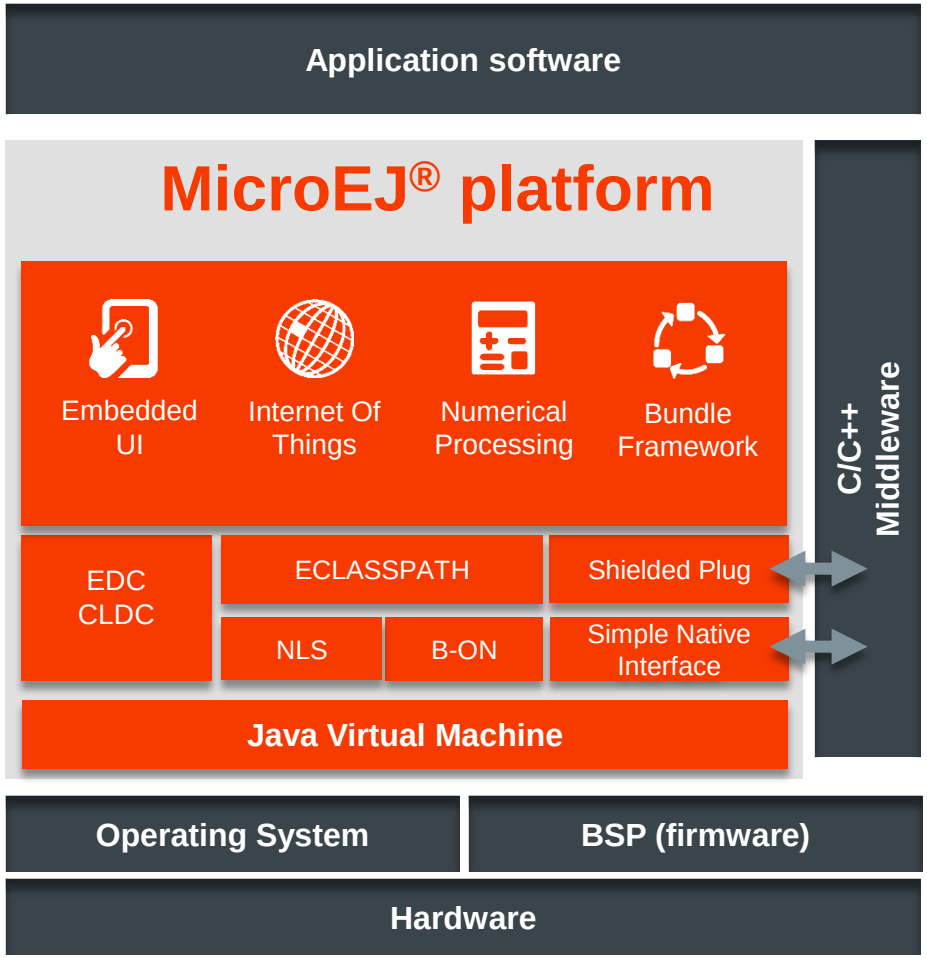


EMBED JAVA TO A LEGACY C BASED APPLICATION

MicroEJ Embedded Devices Edition

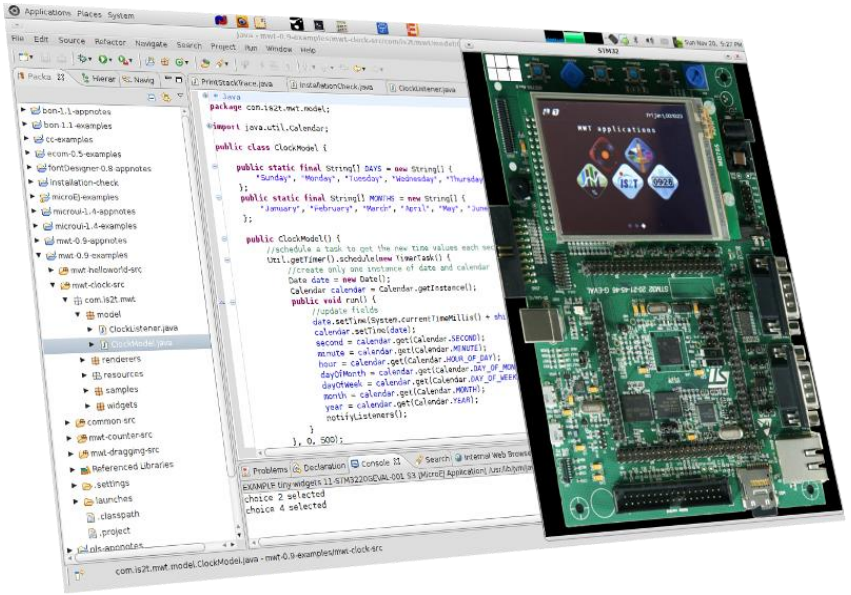
What is a MicroEJ Embedded Platform?

- Dual Java Platform
  - » Embedded platform (EmbJPF)
  - » Simulated platform (SimJPF)
- Integration with legacy
  - » RTOS if any
  - » Firmware & Driver
- General purpose
  - » CLDC/EDC, BON, NLS
- Special packs
  - » UI, IoT, Num, SOA



MicroEJ SDK

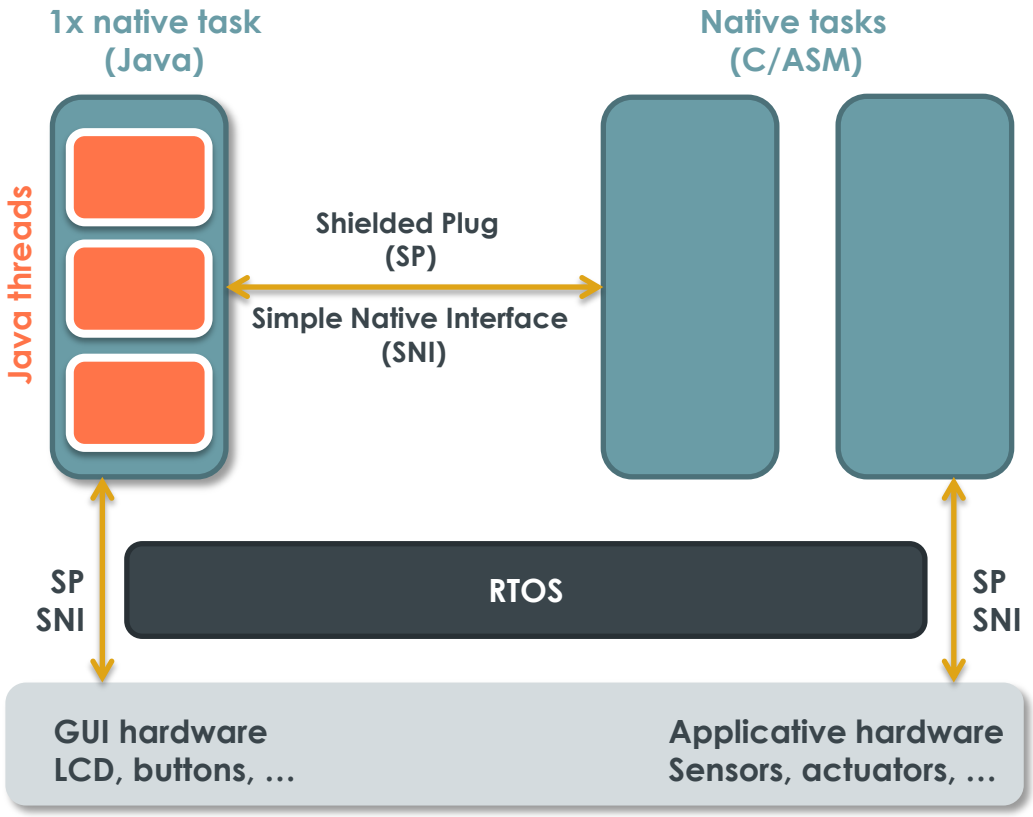
- Java platform design
  - » Integrate to your RTOS
  - » Interface to your C code
  - » Supports ARM-Keil, GNU, IAR, GreenHills, Windriver



- Java application design
  - » Java project editor
  - » Simulate to prototype and debug
  - » Analyze memory usage
  - » Deploy

Easy RTOS Integration (Green Thread)

- Multi-threaded Java execution environment within a single RTOS task



RTOS Examples

- µC/OS, ThreadX, RTX
  FreeRTOS
- Linux, Integrity, VxWorks
- Your RTOS!

Easy RTOS Integration (Green Thread)

- Same Java thread scheduling policy for all RTOS
  - » Portability improved
    Not only at binary level, but also scheduling level
- Easy control of CPU resource usage for Java world
  - » Java RTOS task priority setting for Java world
  - » CPU resource allocation irrespective of the number of threads
- Java threads & native Tasks synchronization means
  - » Allows synchronous and asynchronous Java / native calls

Easy Java → C Interface (Calls 1/2)

- SNI (ESR 012) : Simple Native Interface
- Call Java world → C/asm
- Arguments: base types (int, float, double , char)

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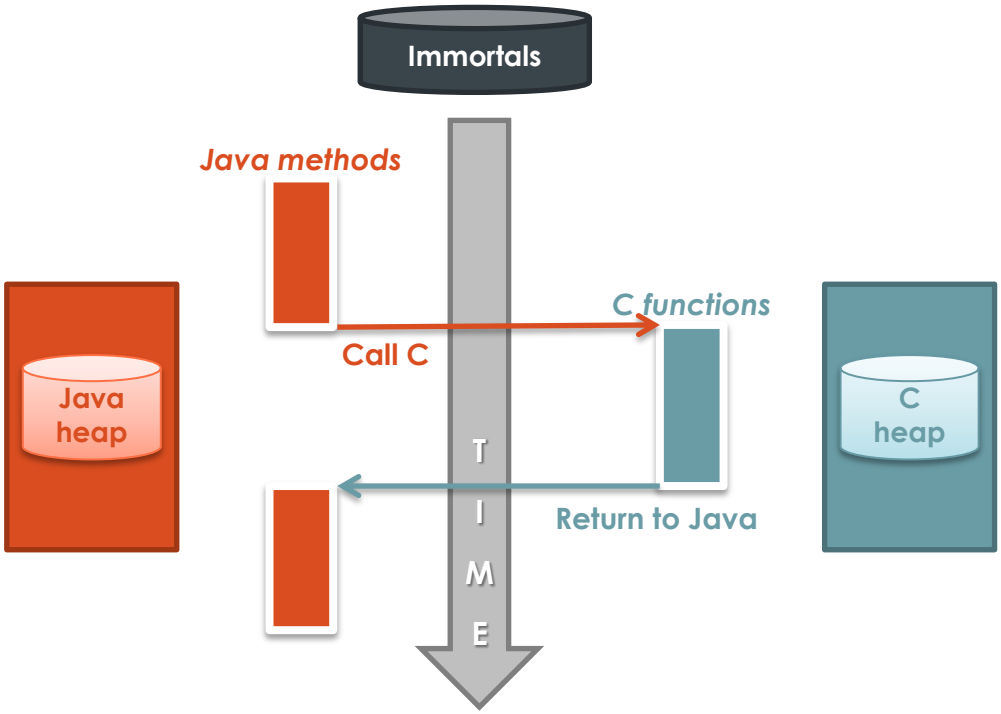

Easy Java → C Interface (Calls 2/2)

- Easy mapping using naming convention

```
package GPIO;

public class Main {
    public static native void toggle();

    public static void main(String[] a) throws InterruptedException
{
        while(true){
            toggle();
            Thread.sleep(10);
        }
    }
}
```

```
#include <sni.h>
#include "gpio.h"

void Java_GPIO_Main_toggle(){
    GPIOE->ODR ^= GPIO_Pin_2 ;
}
```

Easy Java ↔ C Interface (Data 1/2)

- SNI (ESR 012): Simple Native Interface
- Share arrays of base types
- Zero copy buffers and compatible with DMA systems

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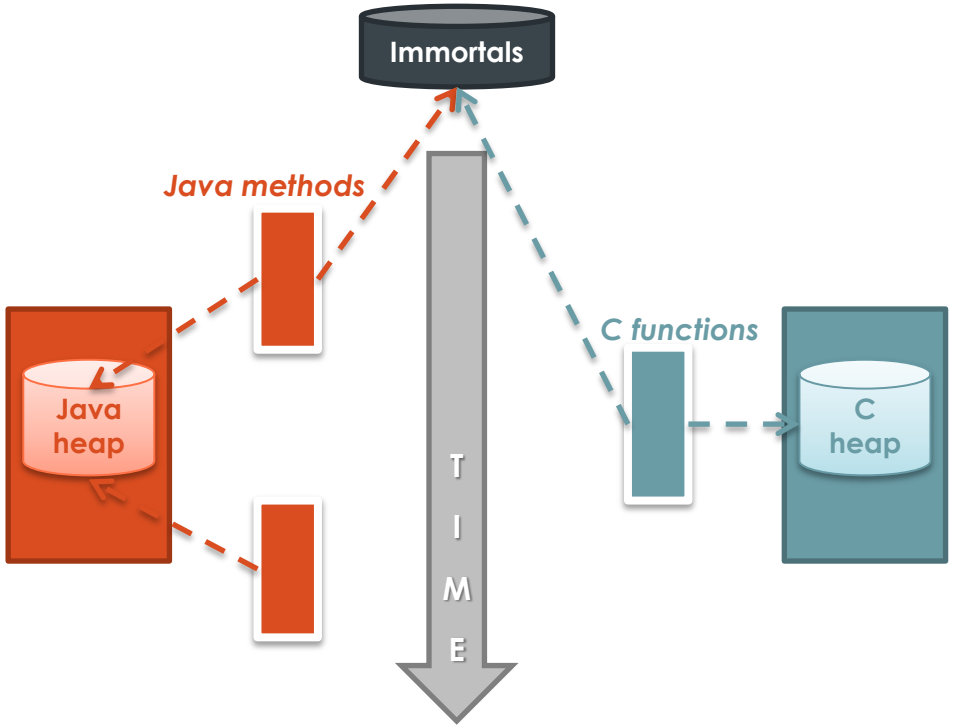


Java → C Interface

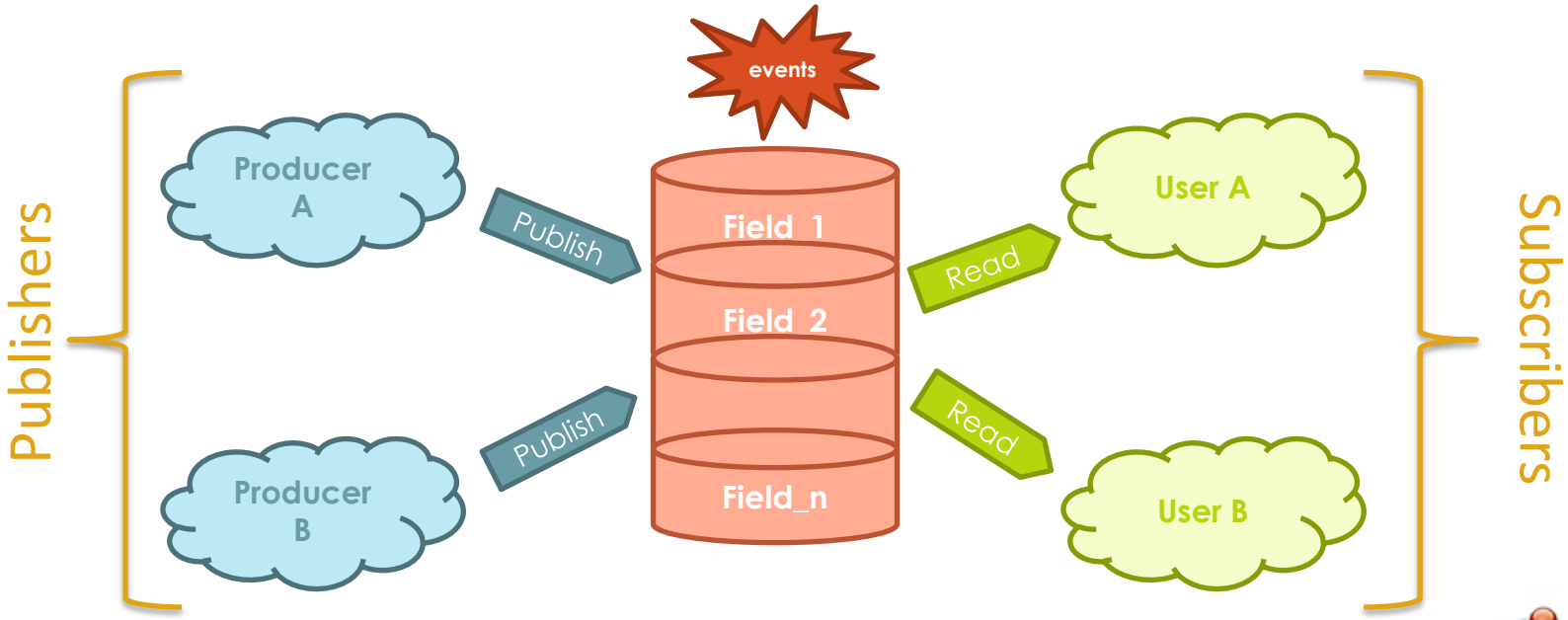
- Immortals are used to share data memory between Java and C

```
package com.corp.examples;
public class Hello {

   static int[] array = (int[])Immortals.setImmortal(new int[50]);
   public static native int getData(int[] array);

   public static void main(String[] args){
      int nb = getData(array);
   }
}
```

```
#include <sni.h>

jint Java_com_corp_examples_Hello_getData(jint* array){
    array[0] = 0xBEEF;
    return 1 ;
}
```

Shielded Plug for Safe & Easy C Integration

- Communication between two separated worlds (Java & native like C/asm)
- Pooling or notification event types
- Spatial & temporal decoupling
- Ideal to add Java tasks on top of a legacy C program



Shielded Plug Java Read Example

```
<shieldedPlug>
          <database name="Forecast" id="0" immutable="true" version="1.0.0">
          <block id="0" name="WIND" length="8" maxTasks="1"/>
          <block id="1" name="TEMP" length="4" maxTasks="1"/>
          <block id="2" name="THERMOSTAT" length="4" maxTasks="1"/>
          </database>
</shieldedPlug>
```

```
public class Wind {
          public int speed; //in ms [0..]
          public int direction; //in degree [0..360]
}
```

```
public class WindReader implements SPReader {
          private static final int SPEED = 0;
          private static final int DIRECTION = 4;
          public Object readObject(ShieldedPlug database, int blockID) throws
                                                                    EmptyBlockException {
                    Wind w = new Wind();
                    byte[] data = new byte[database.getLength(blockID)];
                    database.read(blockID, data);
                    w.speed = ByteArray.readInt(data, SPEED);
                    w.direction = ByteArray.readInt(data, DIRECTION);
                    return w;
          }
}
```

Shielded Plug C Publish Example

```
#include <sp.h>

struct Wind {
        int32_t speed;
        int32_t direction;
};

void windPublication(){
        struct Wind w;
        ShieldedPlug database = SP_getDatabase(Forecast_ID);
        w.speed = speed();
        w.direction = direction();
        SP_write(database, Forecast_WIND, &w);
}
```

Extend the Simulation Platform

- Why building your simulator?
  - » Prototype before having hardware available
- Build your virtual device for UI
  - » Front Panel Designer (buttons, LCD display, LEDs, etc.)
- Build your peripheral extensions (mocks)
  - » Software mocks in Java or C connected to the simulation engine
  - » Hardware mocks over workstation communication interfaces

Extend the Simulation Platform

```
public void runTest(Display display,
String message) {
  MessageViewable viewable = new
MessageViewable(display);
  viewable.init("Hello, world!);
  viewable.show();
 }
```

Application

```
public static void blink() {
  while (true) {
    toggle();
    try {
      Thread.sleep(1000);
    } catch (InterruptedException e) {
  }
}
public static final native boolean
toggle();
```

Simulated Java Platform

Mock Front Panel

JVM (S3)

Native Interface

Mock Interface

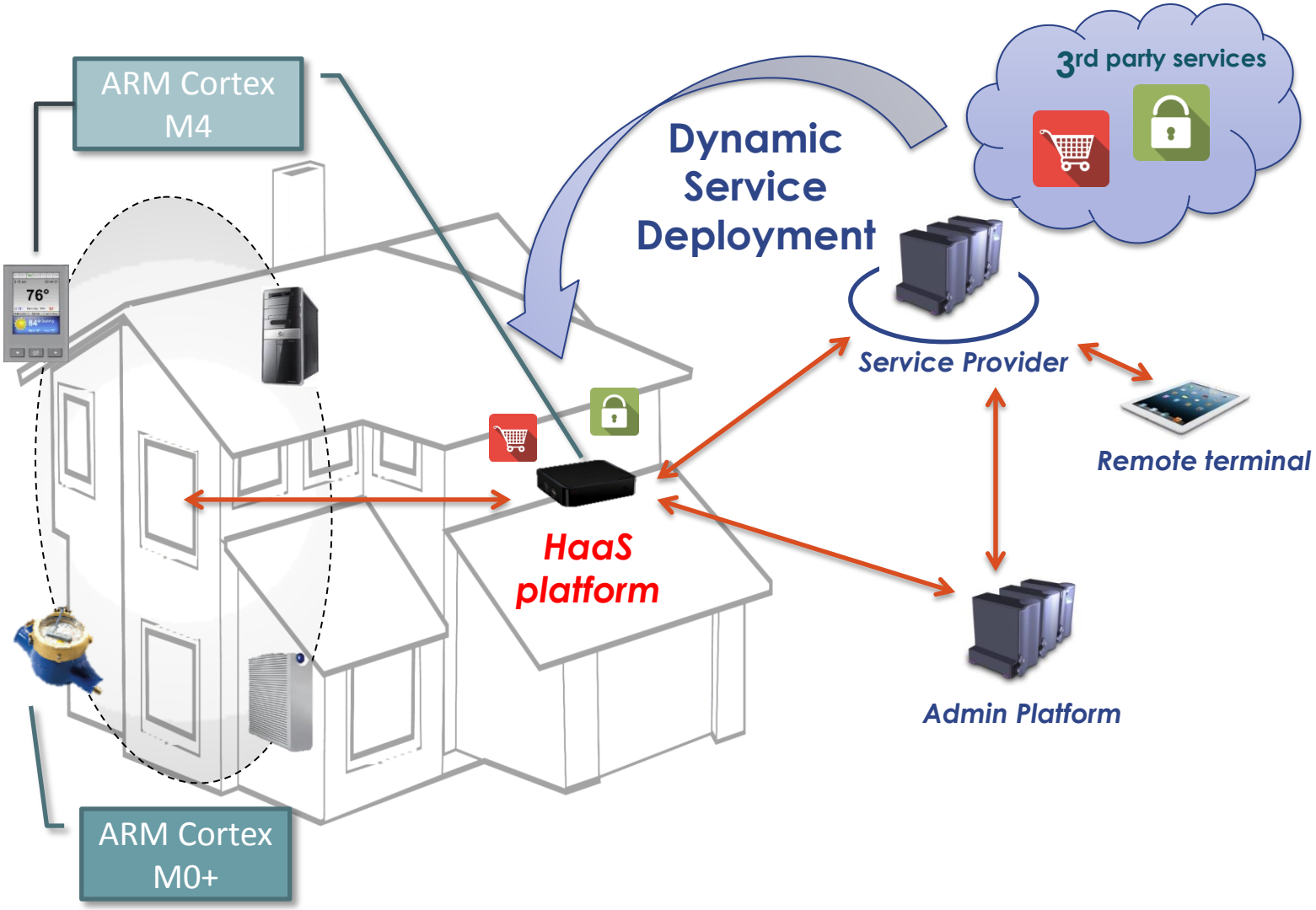
Mock Custom (LED)

```
public class LED {
  private boolean state;

  public static boolean
toggle() {
    state = !state;
    if (state) {

drawImage("ledOn.png");
    } else {

drawImage("ledOff.png");
    }
  return state;
  }
}
```

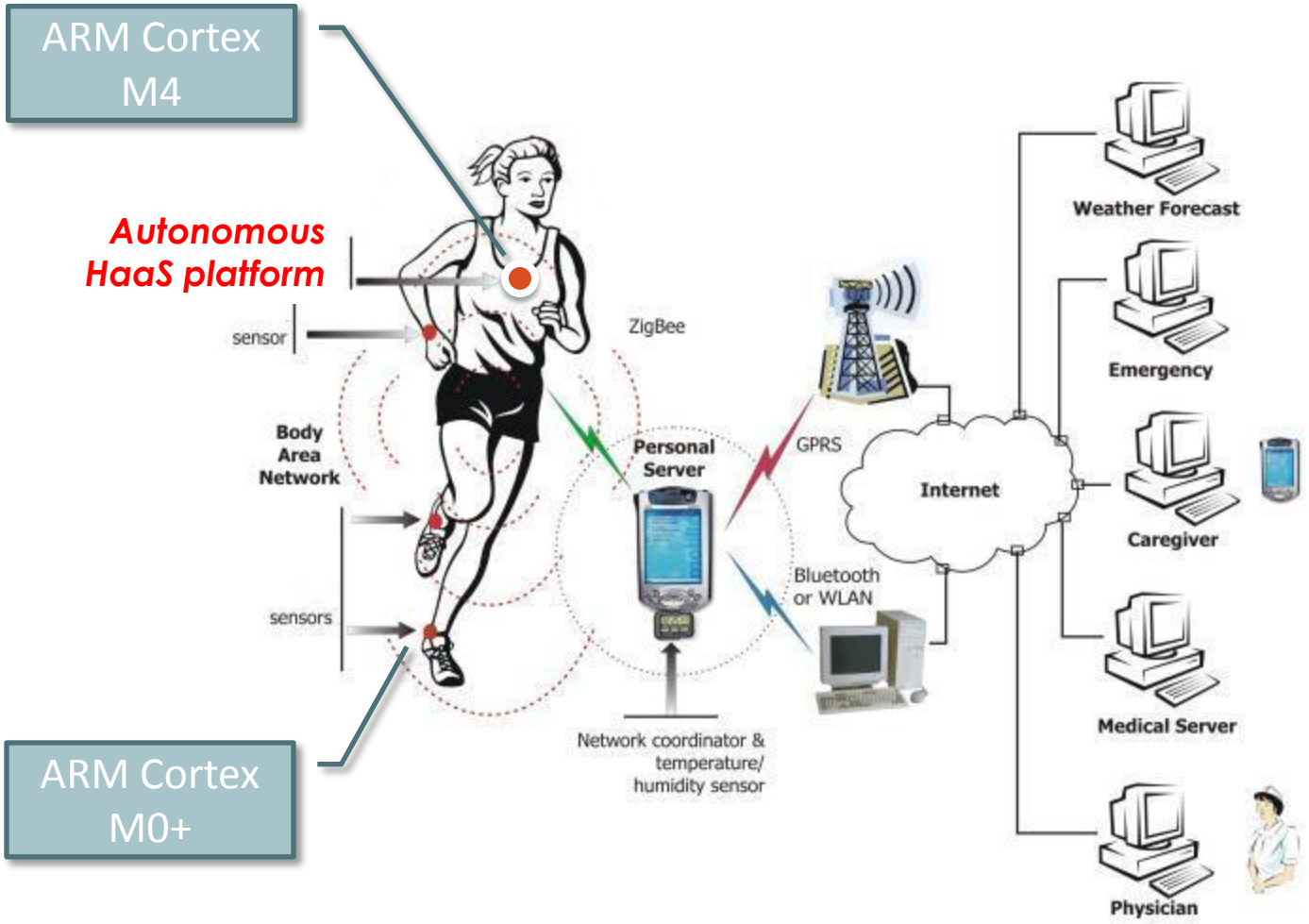
APPLICATION PLATFORMS FOR SMART OBJECTS (IOT)

MicroEJ - Hardware as a Service

HaaS for Home Energy Management



HaaS for Wearable Electronics



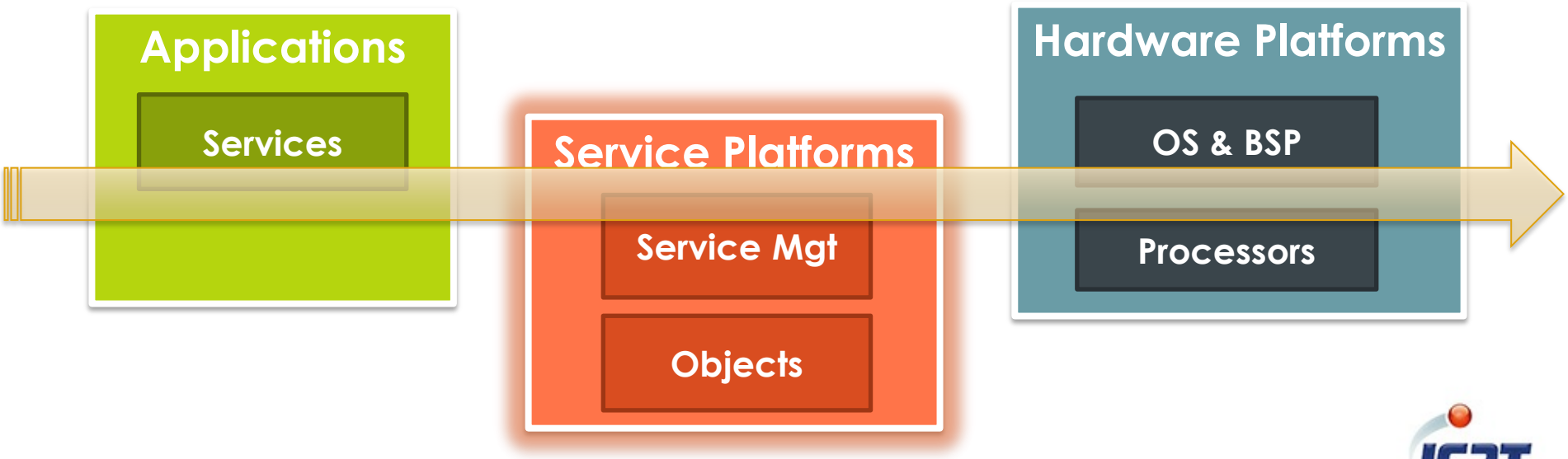
IoT Market Challenges

- Energy efficiency
  - » No bloatware!
- Cost Effectiveness
  - » Small execution environments
- Rich Eco-Systems
  - » More software enablers for innovative business models
- Reliability
  - » Data integrity, service management
- Security
  - » Virtualization, resource management

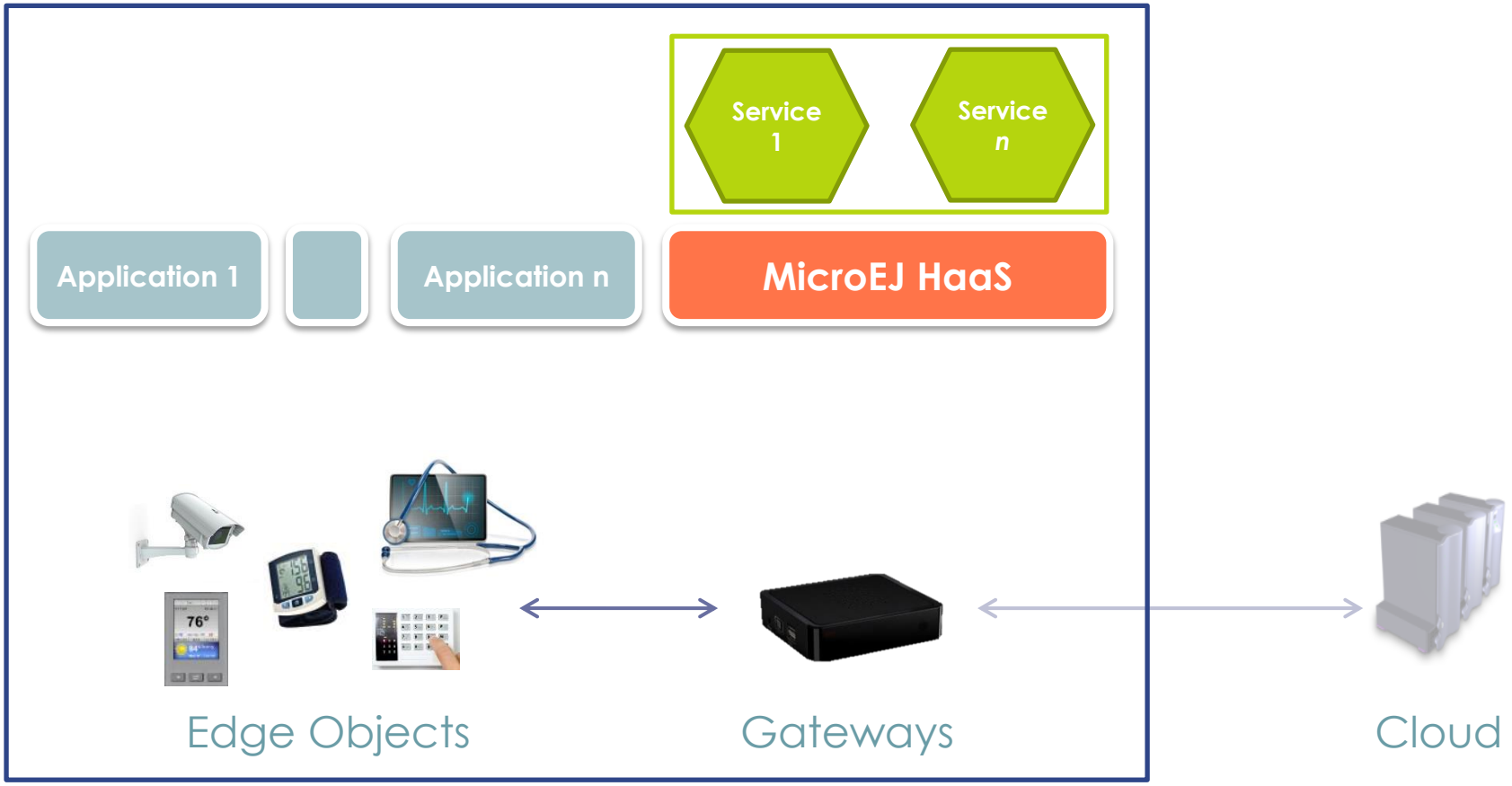
Solution Alignment

- Various topologies for gateways and edge devices
- Time-to-Market can not wait for specific system availability

⌦ *Need unified and portable execution environments*



HaaS Platform Overview

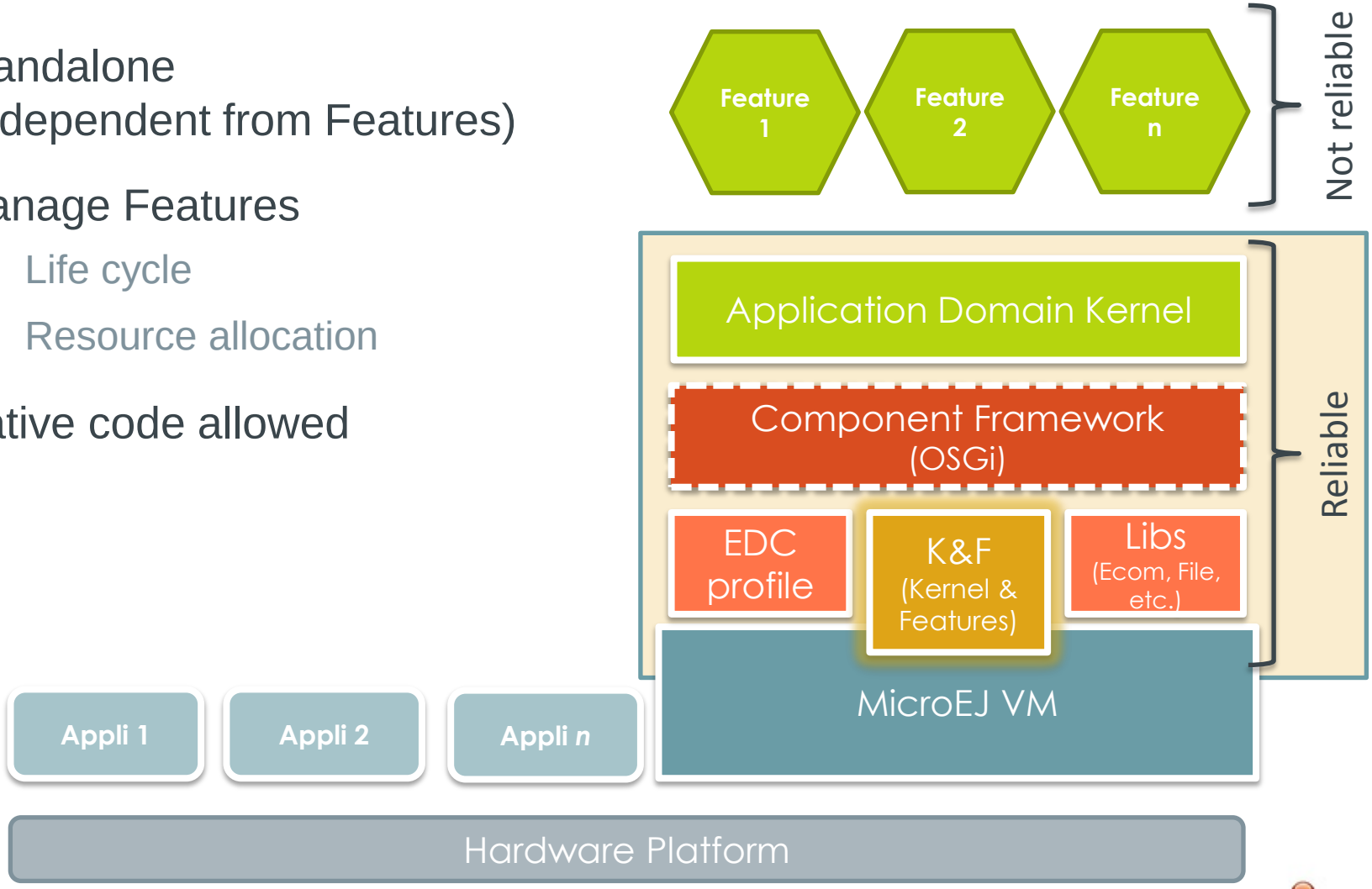


New Capabilities

- Let marketing try new ideas
  - » Try new services fast
- Share your platform with your Eco-System
  - » Provide an open platform with safe isolation capability
- Let your customer choose a product configuration
  - » In the field dynamic service deployment and activation
- Keep using your legacy device base
  - » Use ubiquitous technology with low constraints on hardware

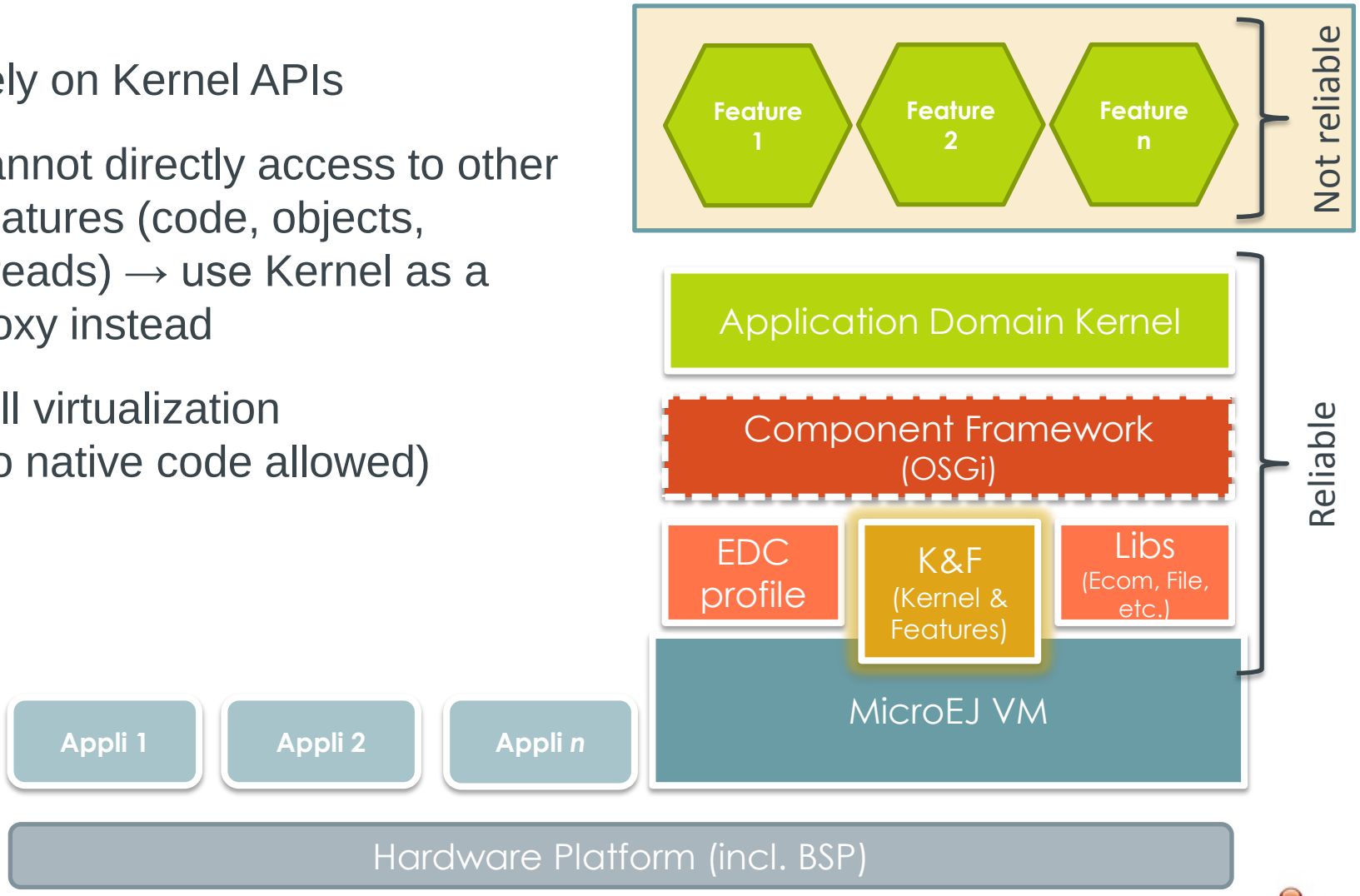
MicroEJ® Haas Architecture – Kernel

- Standalone (independent from Features)
- Manage Features
  - » Life cycle
  - » Resource allocation
- Native code allowed



MicroEJ® HaaS Architecture – Features

- Rely on Kernel APIs
- Cannot directly access to other Features (code, objects, threads) → use Kernel as a proxy instead
- Full virtualization (no native code allowed)



K&F Key Features

- Low consumption & OS agnostic
  - » Kernel & Features: ~20KBytes
  - » Run the same on any RTOS
- Ressources management
  - » CPU and memory allocations
  - » All I/O : file system, TCP/IP, UART, USB, etc.
- Stable & Secure
  - » Kill of a Feature (group of bundles) feasible at any time
    - Threads + objects + code
  - » No back door

K&F and OSGi

- Bundle life cycle management
  - » Load/unload, enable/disable
- Resource management
  - » Bundles cannot access to larger CPU and memory resources than required
  - » Bundles cannot access to physical resource when not allowed to
- Isolation
  - » Bundles is isolated from each others and interface according to the rules defined by the Kernel
- Stable & Secure
  - » Unload has no impact on other Bundles
  - » No stale reference, no zombie threads, etc.

THANK YOU!

More information: www.is2t.com

Evaluation kits: is2t.microej.com