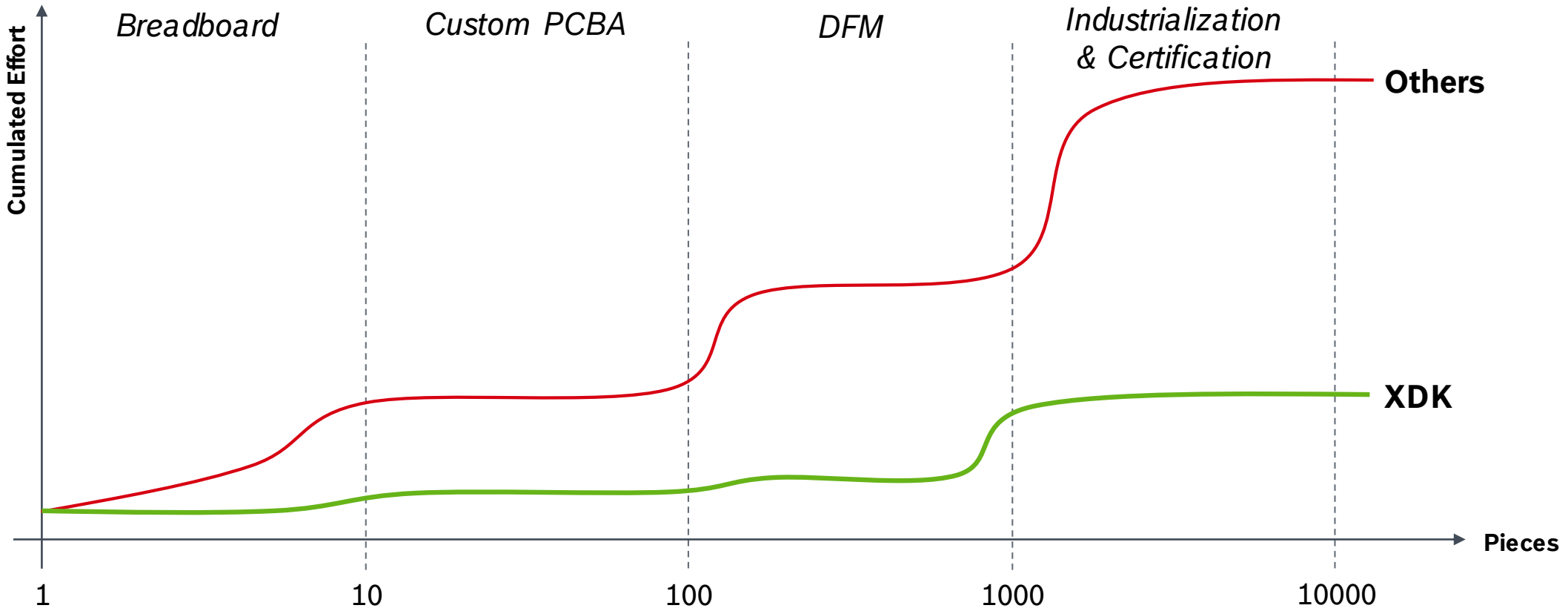
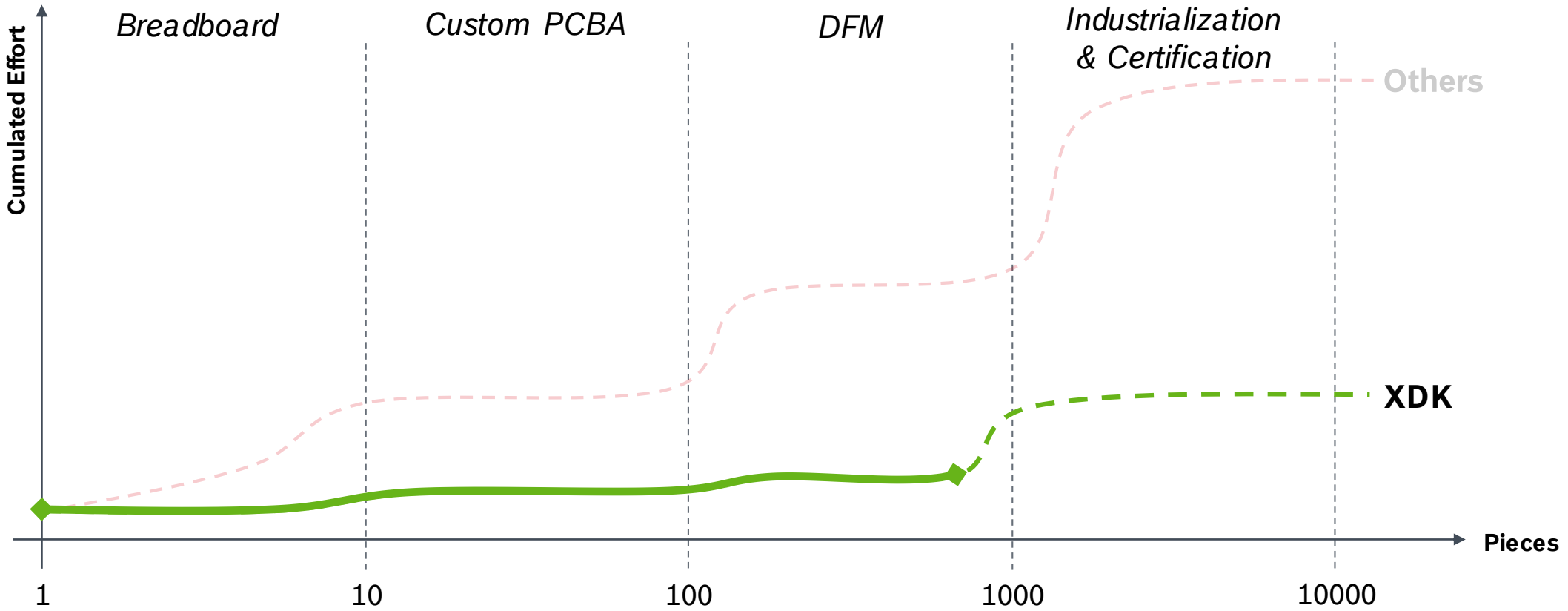
LANGUAGE FOR THE EMBEDDED IOT

BOSCH

Eclipse PAX
Scaling over quantity



Eclipse PAX
Scaling over quantity



Eclipse PAX
Scaling through integration

- Accelero-meter
- Gyroscope
- Magneto-meter
- Humidity sensor
- Pressure sensor
- Temperature sensor
- Acoustic sensor
- Digital light sensor
- 32-bit Microcontroller ARM
- Wireless LAN
- Bluetooth LE
- Li-Ion rechargeable battery

Eclipse PAX

We need a way to program that

Lowers barriers

- Familiar and easy to learn
- "Feels" good
  → user centred design
- Convenience matters
  → high abstraction
- Doesn't annoy power users
  → high ceiling
- Enable IoT development for new user groups

Scales to production

- Afford a lot of control → go really low level
- Based on proven infrastructure
  (LLVM on bare metal, e.g. Rust + Zinc or Taylor Swift are still years out)
- Enable trust in software → allow inspection in a world people know

Scales to low-power HW

- Very low runtime impact
- No garbage collection
- Preference for static memory allocation

BOSCH

Eclipse PAX
What about existing languages

- **LUA**
- **Python**
- **mRuby**
- **Javascript**

Widespread adoption but
expensive at runtime and far removed the system

Eclipse PAX

What about existing languages and platforms

Rust	C++	Arduino	mbed OS
Far away from being production ready on bare metal	High “accidental complexity”	Based on C++ / removed from other industry-grade platforms	

BOSCH

Eclipse PAX
Inspired by research

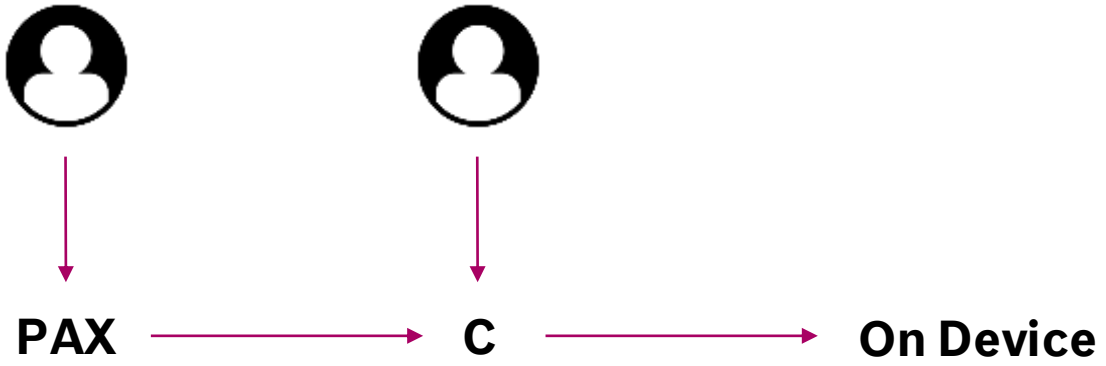
Powerful language (C#) and brilliant IDE support make IoT prototyping more accessible.

People understand what they can see.

→ Direct interaction with sensor data and devices.

Programming as Domain Specific Language (DSL).

Eclipse PAX
Transpiles to C



Eclipse PAX

Base Language

- Imperative
  with future aspirations for functional elements
- Event driven
- Exceptions
  try/catch instead of return
- Extension methods
  provide OO feeling
- String interpolation
  built into the language

Type System

- Statically typed
  with generics and optional types
- Type inference
- Generic Types
- Static Heapless Memory Management
  through Data Structure Size Inference

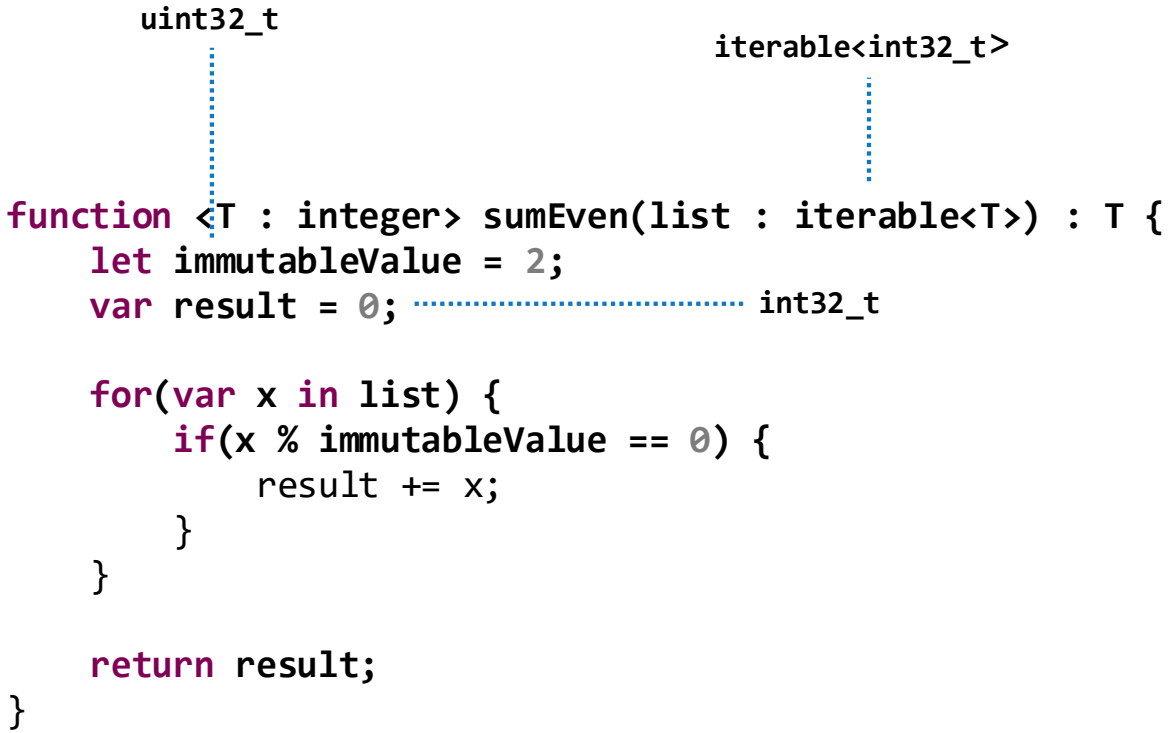
Model-Driven

- Declarative Setup
  of platform-defined system resources
- Direct Access to System Resources
  such as sensors, connectivity and GPIO
- Generic Extensible Platform Support
  not specific to XDK
- Built-in Library Mgmt

Transpiler

- Transpiles to C code
- Traceability between PAX and C code
  (thanks to Xtext > 2.12)
- Variable names, function names and comments are carried over

Eclipse PAX
Imperative and Statically Typed

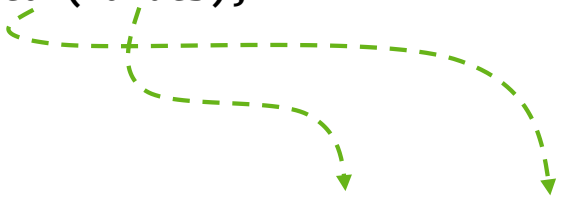


- Language design inspired to TypeScript, Swift, Rust, Scala
- Supports all classic control structures
- Immutable and mutable variables
- Static typing → all expressions have a type at compile time
  - Generics are supported for types and functions

Eclipse PAX
Extension Methods

```
function mean(self : iterable<float>) : float {
    var result = 0.0;
    for(var x in self) {
        result += x;
    }
    return self.sum() / self.length();
}

let values = [0.0, 1.0, 2.0, 3.0];
var meanValueA = mean(values);
```

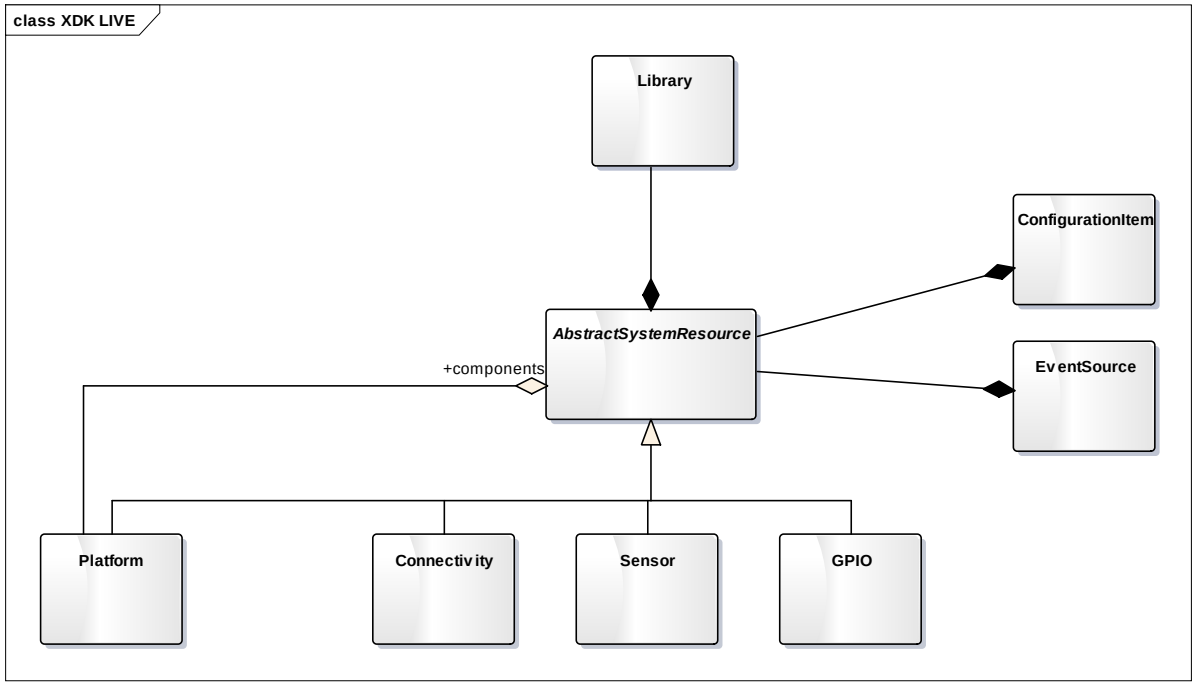


```
var meanValueB = values.mean();
```

- First parameter can be written on left side during function invocation
- Provides an “object oriented feeling”
  - It helps that functions are polymorphic
- Standard library is implemented this way

Eclipse PAX
Declarative Setup

- We need to configure the system we run on
  - Sensors, Connectivity and GPIO
- All of those define “configuration items”
  - Accelerometer Range
  - Bluetooth Advertising Interval
  - SPI clock speed
- All of those can offer events
  - Accelerometer Activity
  - Bluetooth Connection Incoming
  - SPI Slave Message Received



Eclipse PAX
Declarative Setup of Sensors

All setup starts with the **`setup`** keyword

Followed by the resource we want to configure

```
setup accelerometer {
    range = Range_8g;
    activity_threshold = 200;
}
```

Sensors offer platform-defined *configuration* items

Eclipse PAX
Declarative Setup of Connectivity

Connectivity (and GPIO) can be named

```
setup devNetwork : WLAN {
    ssid = "BCDS_DevNet";
    psk = "MySuperSecretPassword";
}
```

Setup connectivity become global variables and can be referenced

```
setup backend : LWM2M {
    transport = devNetwork;
    server = “10.0.0.1”;

    var shockDetected =
        property(url="/1/2", init=false);
}
```

Signals configure things like LWM2M properties, BLE characteristics, REST APIs or GPIO pins

Eclipse PAX
Declarative Setup of GPIO

Every system resource has their own signals

```
setup gpio {
    var externalLed = digitalOut(pin=A4, driveStrength=High);
    var battery = analogIn(pin=B2);
}

setup mySensor : I2C {
    sda = Pins.A1;
    scl = Pins.A2;

    var creg1 = register(address=0x0A, init=0x00 as uint16_t);
    var value = register(address=0xAB, init=0x00 as uint32_t);
}
```

I2C registers mapping, including data type

Eclipse PAX
Direct Access

Access sensor values as if they were variables

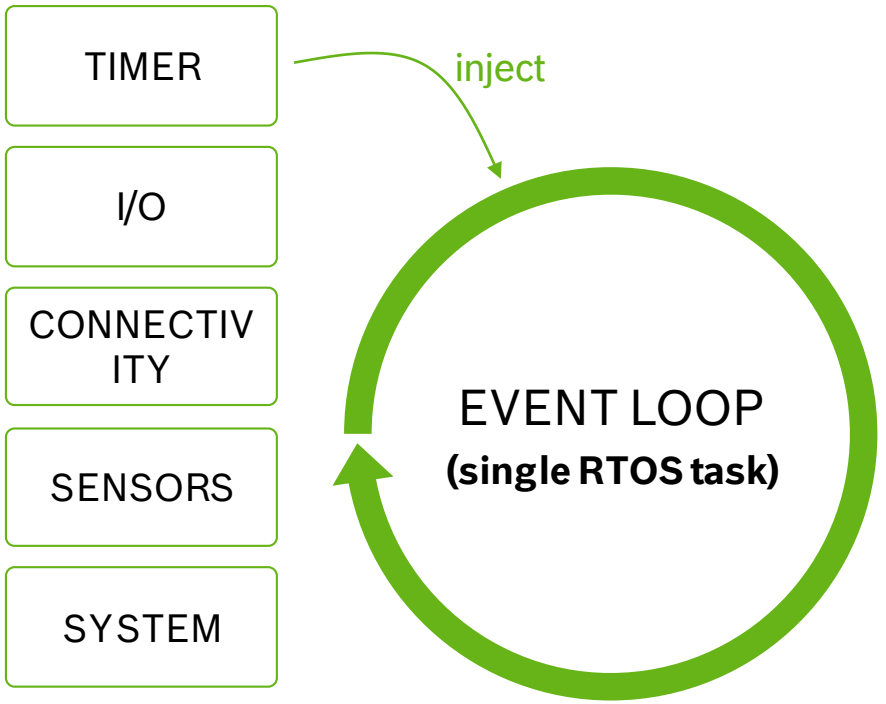
```
every 100 milliseconds {
    if(accelerometer.magnitude > 5000) {
        // TODO: do something
    }
}
```

Eclipse PAX
Event Driven

```
every system.startup {
    // system just started
}

every 100 milliseconds {
    // TODO: do something every 100ms
}

every accelerometer.activity {
    // our device was just moved
}
```



Eclipse PAX
Event Driven

Time

```
5 seconds
100 milliseconds
```

Sensors

```
accelerometer.activity
light.bright
```

Connectivity

```
backend.connected
smartphone.cfgchar.written
```

GPIO

```
gpio.myPin.fallingEdge
```

Eclipse PAX

Where do we go from here?

Eclipse PAX
Where do we go from here?

Eclipse PAX

Is a new programming language for the embedded IoT

Enables high-level features transpiled to C

Is not limited to the XDK

Want to play with this stuff?
http://xdk.io