OSGi ME

An OSGi Profile for Embedded Devices

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André Bottaro, PhD - Orange Labs
Fred Rivard, PhD - IS2T

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fred.rivard@is2t.com / andre.bottaro@orange-ftgroup.com

Agenda

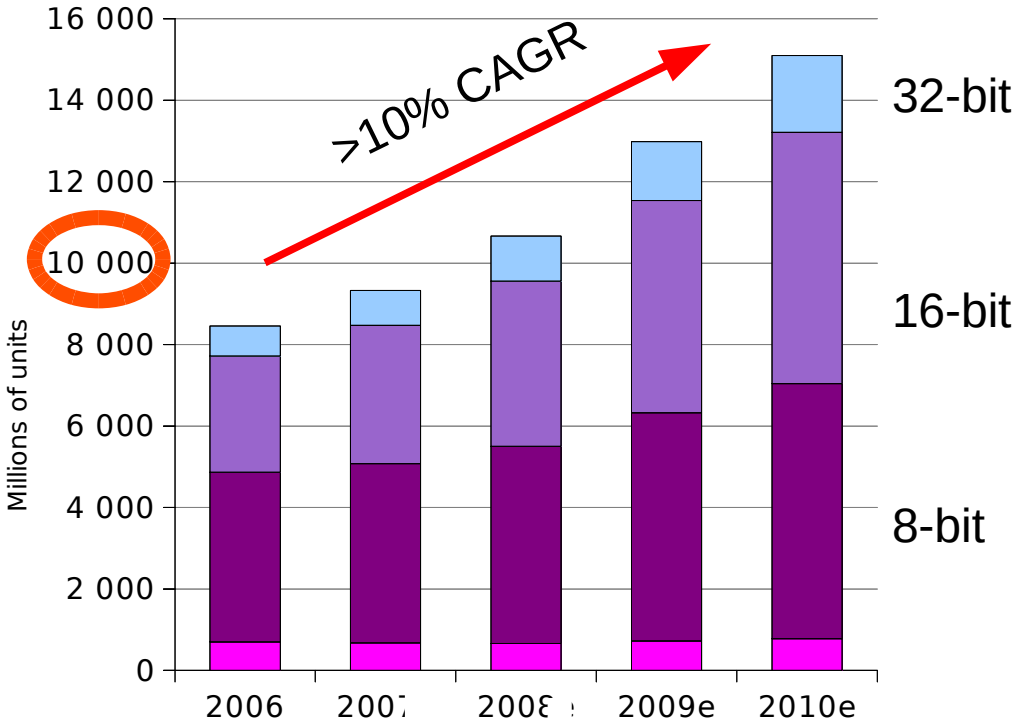
- **The Embedded world**
  - Market size, Market trends
  - Embedded device == Economical device, Technical constraints
  - Life cycle of an embedded device, Bill-Of-Material, Business Models
- **OSGi ME**
  - Why another profile for the OSGi platform?
  - Need to handle the « cost » & « diversity » of embedded devices
- **OSGi ME in a nutshell**
  - Device Software Dynamics (DSD) & business cases
  - Fine-grained code sharing and isolation model
  - Java ME CLDC, OSGi binary compatibility
  - Same ordered initialization sequence (across several reboots)
  - Reliability: transaction, robustness, thread safety

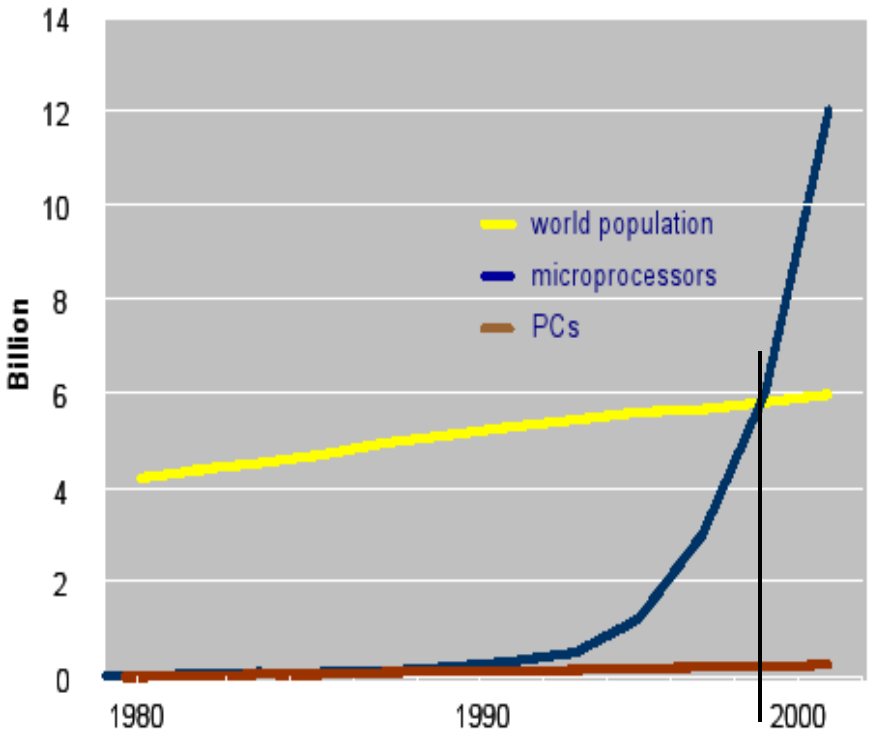
The embedded world Market

- Medical
- Security
- Telecoms
- Handsets
- Multimedia
- Home appliances
- Building automation
- Industrial control
- Automotive
- Transportation
- Defense
- Avionics

The mcu revolution

- The mcu market, the driving force is the 32-bit





2008	growth	
	units #	market $
32-bit	+22.00%	+16.00%
16-bit	+11.00%	+2.00%
8-bit	+8.00%	-5.00%

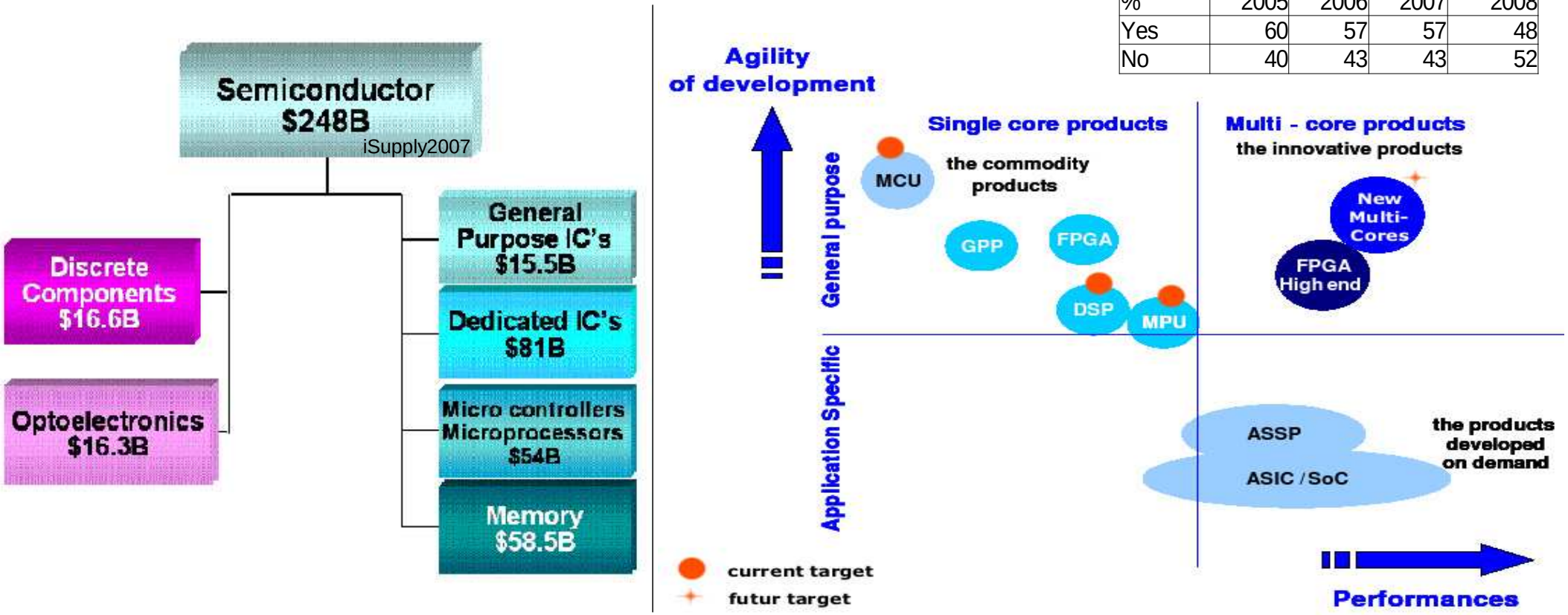
2008	Market share $	Unit price $
32-bit	50%	5.00$
16-bit	25%	1.40$
8-bit	25%	1.00$

2008	New products being designed
32-bit	**59%**
16-bit	20%
8-bit	14%

64-bit: 7%

Semi-conductors Market
The HW part of the embedded device

Application specific for new projects				
%	2005	2006	2007	2008
Yes	60	57	57	48
No	40	43	43	52



- 98% of the processors are used in embedded devices

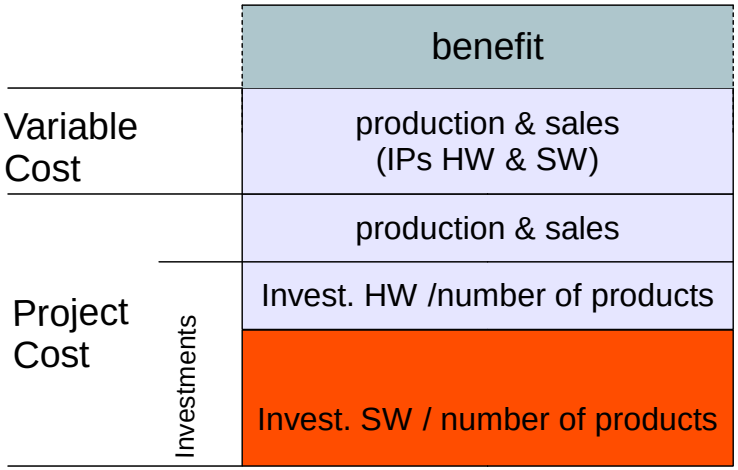
Increased Software Value

- **Strong increase of software value in the added-value of a device**
  - 2003 → 2009: +87%
- **Increased software R&D share in global R&D expenses**
  - 2002: 31% → 2015: 41% (estimation)
- **More software engineers**

2 types of software engineers

Embedded Team Size	2007	2008	%
Sofware Engineers	6.3	8.1	+28.57%
Firmware Engineers	3.0	2.8	-6.67%
Hardware Engineers	4.3	4.3	0.00%
Total	13.6	15.2	+11.76%

- **Project device life cycle: 2 phases**
  - (1) Investment: 2/3 is for software
  - (2) Production: Bill Of Material per unit
  - The volume effect!
    - A small quantity is <75.000 units!



Economical driving forces

- **Reuse**
  - Perpetuate SW and HW investments
  - Obsoleteness of HW and SW

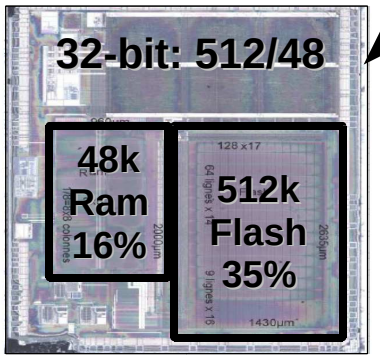
2008

Project duration	13 months
Delay	**4 months**
SW Reuse	85%
HW Reuse	70%
Debug Cost	**25%**

- **Investments decisions based on financial indicators**
  - Need of productivity
  - Time-To-Market, ROI ==> Deliver On Time!

- **Software & Hardware heterogeneousness**
  - High technical constraints: cpu budget, memory, consumption
  - Reliability: certifications, safety critical

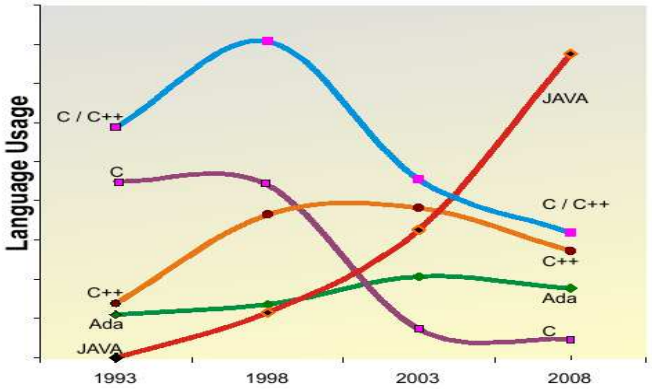
60% new device uses a 32-bit
70% of flash <= 512K
50% frequency <= 100Mhz
70% multi-tasks



The cost of a mcu is its physical footprint, often made of memories (ram & flash)

Software requirements of the EBW

- **A standard software environment ...**
  - Software bricks from distinct service providers implementing common APIs
  - Benefit from the fast and abundant development of a wide community
- **... open to third party applications ...**
  - Unleash creativity by assembling software bundles coming from third parties
  - Accelerate service delivery through an application store
- **... with agile development techniques.**
  - accelerate Time-to-Market with managed code development
  - Ubiquity (against hardware) thanks to code portability



Usage Trends of Ada, C, C++, and Java
Data Source: IEEE Software, May/June 2005, *An Empirical Study*

« For [...] embedded devices, the main consideration is [...] no longer which OS to employ [...] but instead, which application platform to use [...] »
F.A.S.T, European Commission, Nov. 2005

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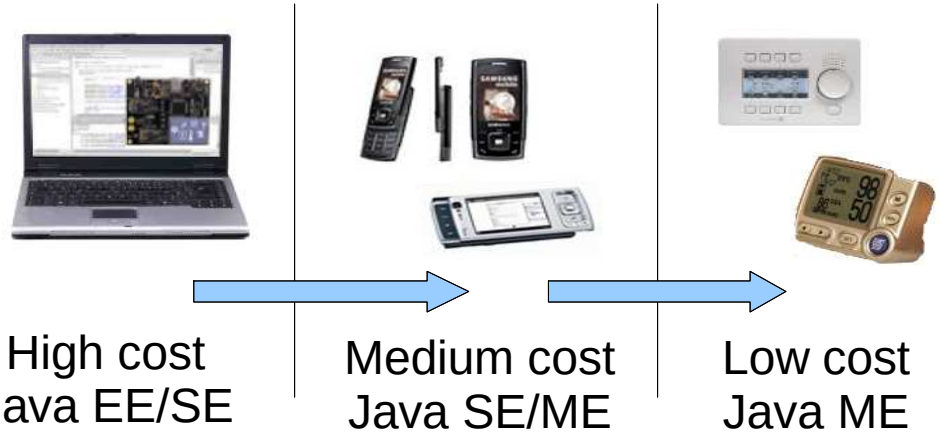
Why an OSGi platform for Embedded devices?

- **Successful on the IT market**
  - Tremendous success on application servers, thanks to eclipse!
- **All OSGi fundamentals apply for the embedded market** (a general-purpose, secure, and managed Java framework that supports the deployment of extensible components)



The market is pulling!

A few success (vehicle, mobile, home) & lots of on-going R&D projects

But OSGi current version is " too heavy "

Technical requirements, like for example class loaders, file systems, ...
Indirect requirement of MB of resources & high frequencies.

Incompatibility with the most widely spread environment: Java ME CLDC.

Need for a new profile to target Embedded Economical Constraints

RFP 126: OSGi ME
Designed for cost reduction

- **Availability of Java ME for typical 32-bit embedded mcu**
  - Typical embedded JVM footprint starts at 40KB (typical Java ME hardware starts with 128KB of flash and 32KB of ram: ARM7, Cortex M3, AVR32, etc... with frequency ranging from 8 to 72Mhz)
  - Some JVM are bare metal with startup time below a few milliseconds
- **Driven by embedded markets business cases**
  - Keep OSGi high value features:
    - Fine-grained code sharing and isolation model
    - Dynamic software management (runtime, compiletime, linktime)
    - Software flexibility and openness to Third Parties
    - Compatibility with a wide range of devices: from sensors to multi-service boxes
  - Only about Java (no native features handling in the specification)
  - CLDC Compliant & “Upward binary” compatibility of OSGi ME to OSGi
- **Orange Labs & IS2T: the RFP 126**
  - Orange & IS2T for the specification, IS2T to design one implementation.

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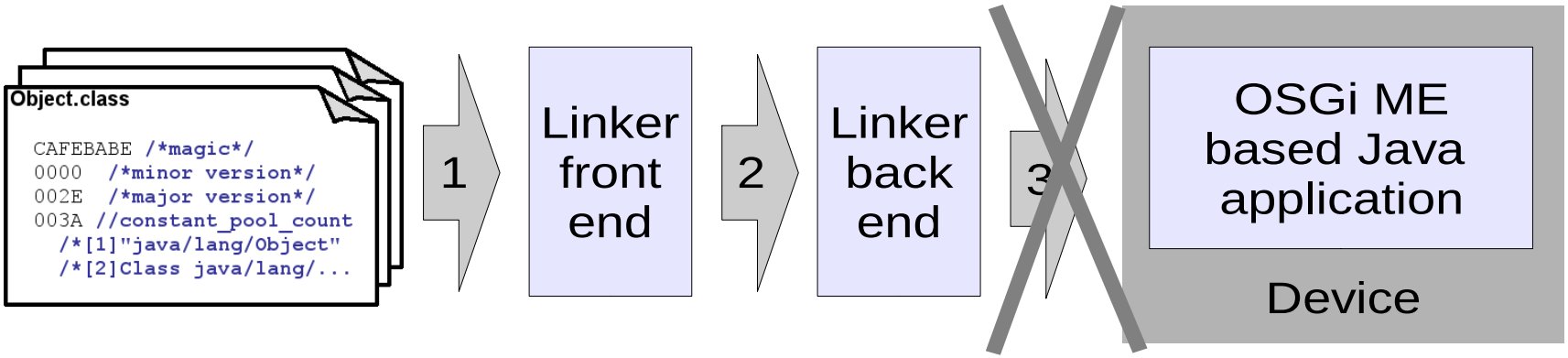
Device Software Dynamics (DSD)

- **Different market requirements on binary code downloads**
  - 1st case: No download due to certification, B.O.M., threats
  - 2nd case: Controlled downloads for only well-known (approved) services, with threat control, proprietary protocols via proprietary media, e.g., uart, spi, i2c, CAN
  - 3rd case: Authorization of any download from any kind of sources

- **DSD levels characterize how binary code is loaded into devices**
  - DSD 0 = no download
  - DSD 1 = download through a controlled media
  - DSD 2 = no restriction

DSD 0

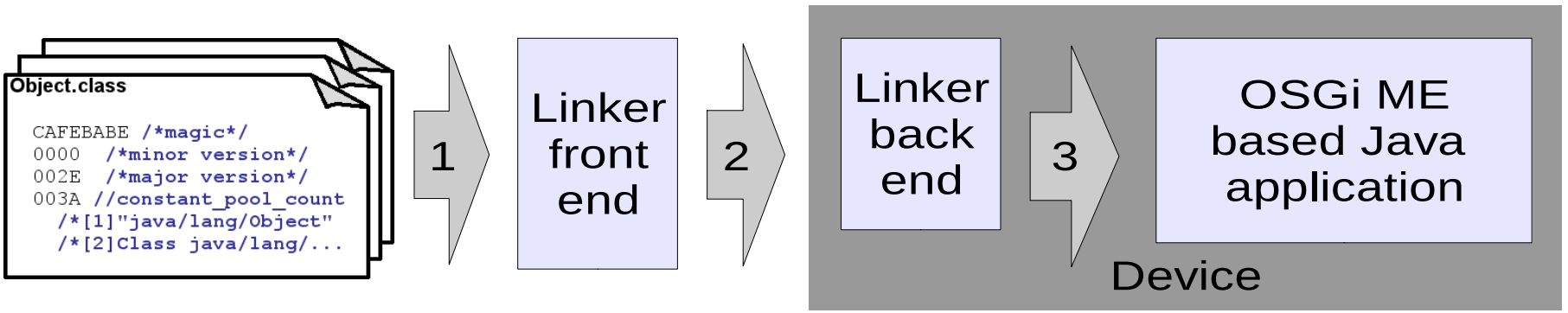
- **The code is loaded using some probe, e.g., JTAG, or bootloaders**
  - The device needs to be “switched off” to download the application
  - No runtime download



- **A closed system**
  - OSGi ME to design a component based application
  - The whole application is known at link-time (drivers, native codes, JVM, OSGi ME, CLDC and others libraries, the user Java application)
  - Only off-board Linking is feasible

DSD 1

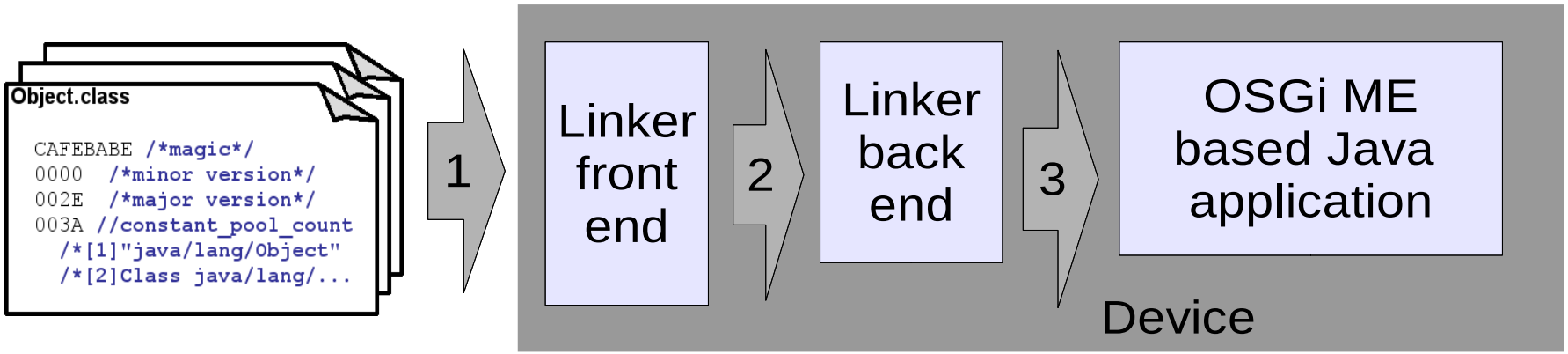
- **Code loading under strict control**
  - The media by which the code gets downloaded to the device is controlled by some technical means, most probably protected by some proprietary protocol.



- **A controlled system**
  - OSGi ME to design a component based application
  - The application can download known bundles at runtime
  - Pre-linking and off-board pre-analysis is feasible
  - Adding and/or Updating are feasible

DSD 2

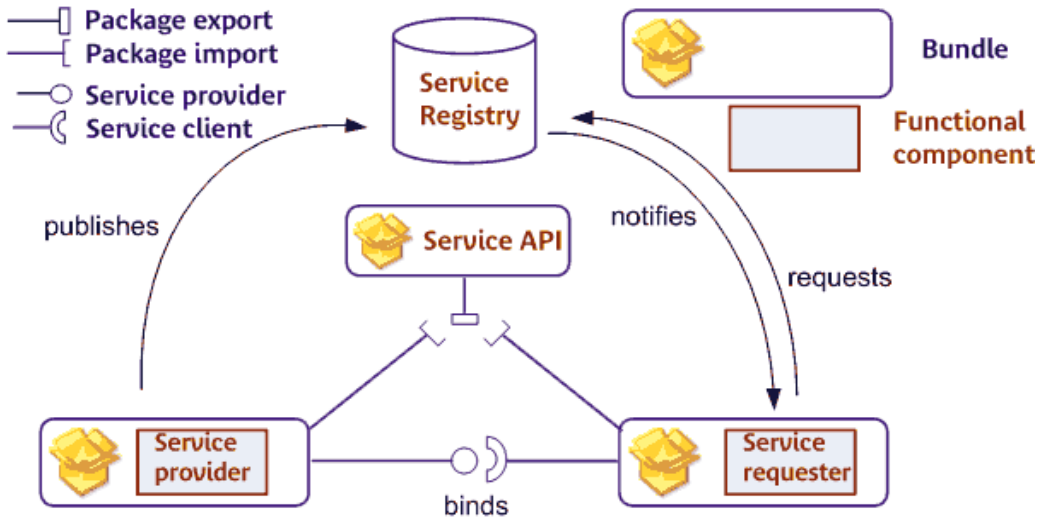
- **Free downloads**
  - The device has to embed all the necessary protections.



- **A fully open system**
  - OSGi ME to design a component based application
  - The application can download any bundle at runtime
  - All linking is done on-board
  - Adding and/or Updating are feasible without reboot

Fine-grained code sharing and isolation model

- **Fine-grained code sharing and isolation between software bundles**
  - The foundation of the openness to third party application



- **Service-Oriented programming relies on sharing and isolation**
  - Service clients and providers share public APIs
  - Service providers hide implementation details
  - Service clients use service providers through public APIs

Java ME CLDC compliance & OSGi Compatibility

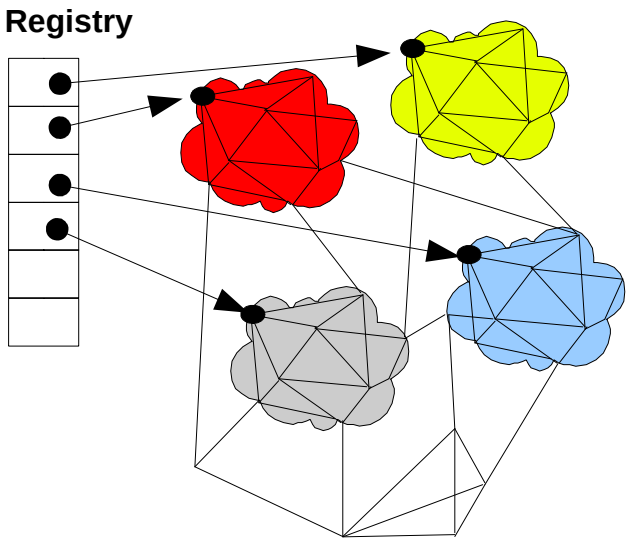
- **The most wide spread Java runtime**
  - Thanks to the mobile phones industry
  - One good property, small: it is ~50KB for the whole library
  - Small implies “less-code-to-execute” so turns to be fast.
- **Source compatibility**
  - Upward: An OSGi ME Java source is always compatible with OSGi.
  - Downward: Automatic tools to turn OSGi bundles into OSGi ME bundles
- **Binary compatibility**
  - Upward: a tool can always turn any OSGi ME binary bundle into a valid OSGi bundle
  - Downward: same kind of restrictions as for source compatibility

Device (Java) initialization

- **Initialization of Java code: the intent**
  - "*The intent here is that a type have a set of initializers that put it in a consistent state and that this state be the first state that is observed by other classes.*" (JVM specification section 2.17.4)
- **OSGi ME re-enforces this intent: unambiguous start-up sequence**
  - No possible deadlock while the (Java) device starts.
  - Uniqueness of the "first-state" (same for each device's start).
- **When DSD > 0**
  - Compatibility of downloaded bundles arrival with the initialization semantic
  - Group-of-bundles: within a group, bundles are ordered according to the initialization sequence (whatever is that order until it is compatible with the Java semantic).
  - Persistent storage: ordered "groups-of-bundles"

Robustness: stale reference

- **No stale reference**
  - A faulty service cannot cause the failure of the entire platform
  - A service == a graph of cooperative objects, with a root that is registered into the Registry
  - The ability to attach/detach objects from others
  - Accessing a dead service throws a runtime exception
  - No manual service reference counting.



- **Responsibility of using a service**
  - Need to anticipate a possible dead service
  - Provisions for such situation (same as exception handling)

Robustness: thread safety

- **Thread Safe framework**
  - Any method can be called several times from several threads concurrently on the same receiver without jeopardizing the state of that receiver.
  - The user application may be synchronized on any accessible object of the framework without causing a deadlock with the implementation of the underlying platform.
- **Small number of critical sections**
  - This definition allows the number and the size of critical sections to be minimized, without compromising the robustness of the framework.
  - The user is free to synchronize its application design according to its need without risking mysterious deadlocks.

Robustness: transaction

- **Reliability**
  - Each thread posses a unique transaction it can enter in, several times (beginTransaction, endTransaction).
  - While executing a transaction, all modifications on objects cannot be seen by other threads
  - If an exception occurs while the transaction executes and is not caught inside the transaction, an exception is be thrown at the beginning of the transaction.
- **Memory side effects visible at the end of the transaction**
  - Upon success, all modifications are made visible to others threads. All the assignments are made sequentially, at no particular order, and not necessary atomically.
  - Use of regular synchronized statements when required by the application

Removal of all “too rich” features

- **Avoid complex features**
  - Hosting (exporting) several versions of a same class
- **Removal of features that are against a strict sharing and isolation declarative model**
  - dynamic imports
  - optional imports
  - bundle requirements
  - bundle fragments
  - bundle extensions

Conclusion

- OSGi ME requirements
  - Keep the core features of the OSGi technology,
  - Be compliant with Java ME CLDC,
  - Simplify OSGi technology for simpler needs,
  - Strengthen robustness.

- **Your feedback is welcome to reinforce the current proposal**

OSGi ME

thank you

fred.rivard@is2t.com / andre.bottaro@orange-ftgroup.com