First year review WP2 overview

Trento - September 24th, 2007

Goal

- To investigate software-only methodologies to implement the remote entrusting principle

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- GEM

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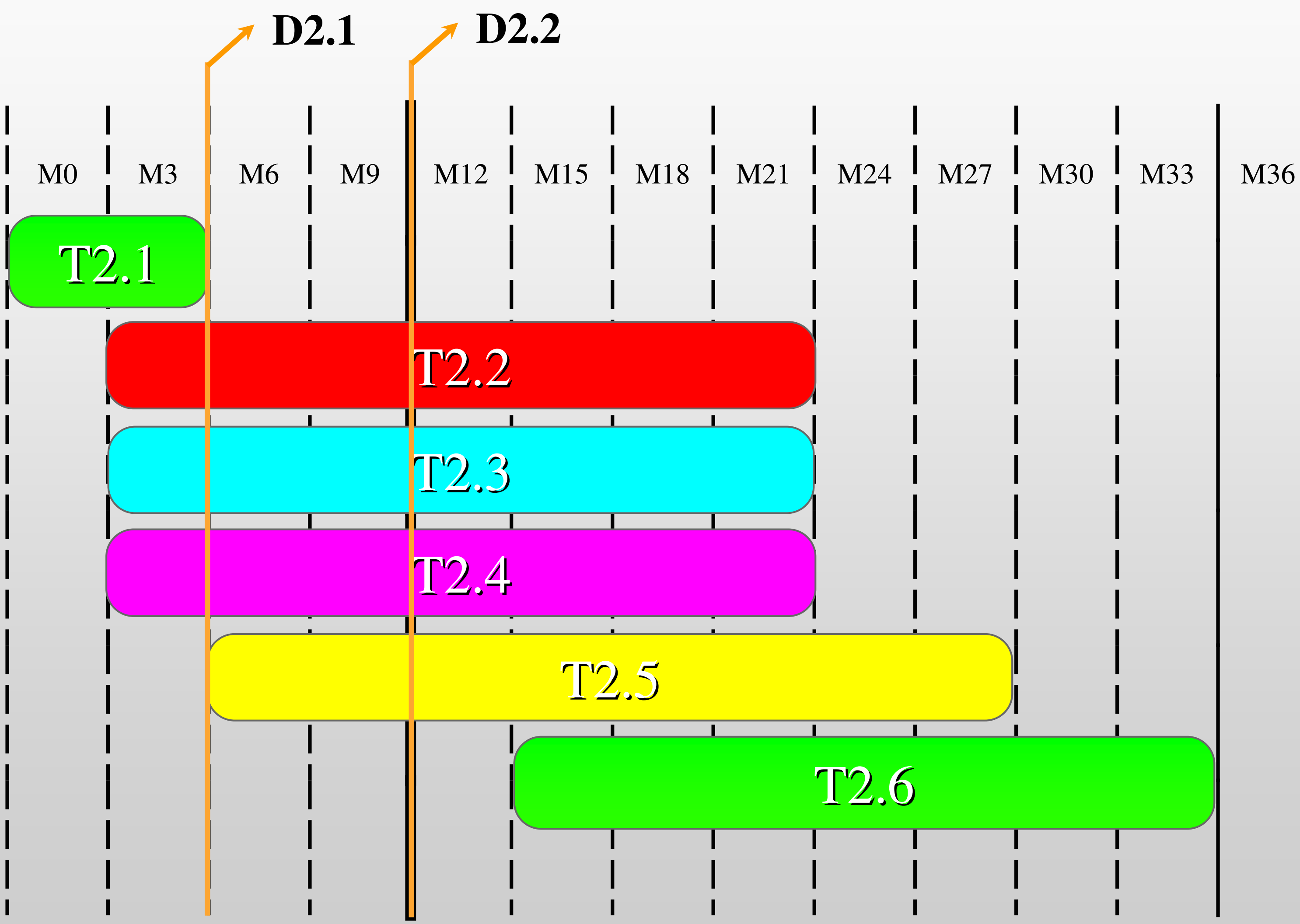
Tasks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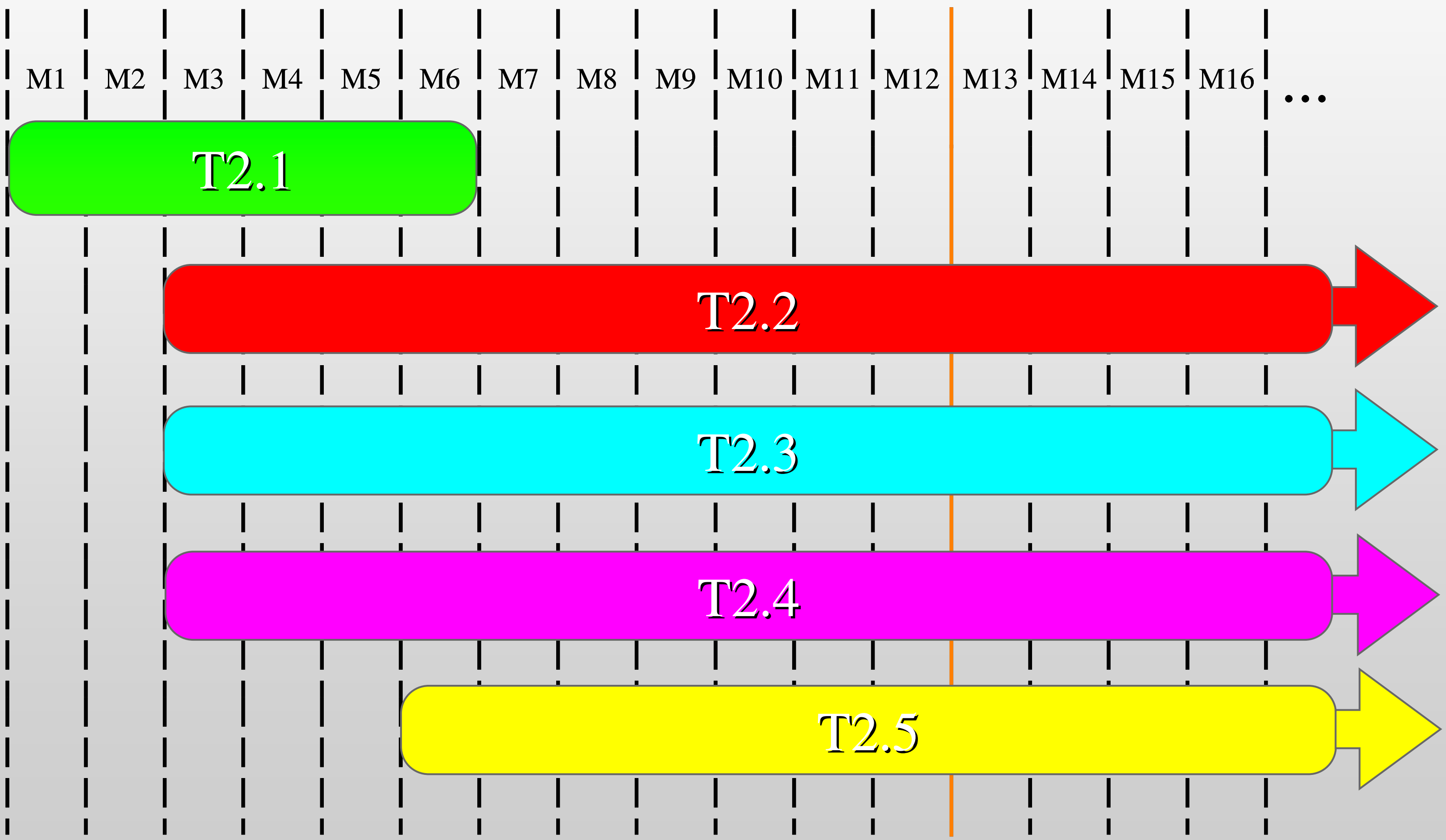
Tasks

T2.1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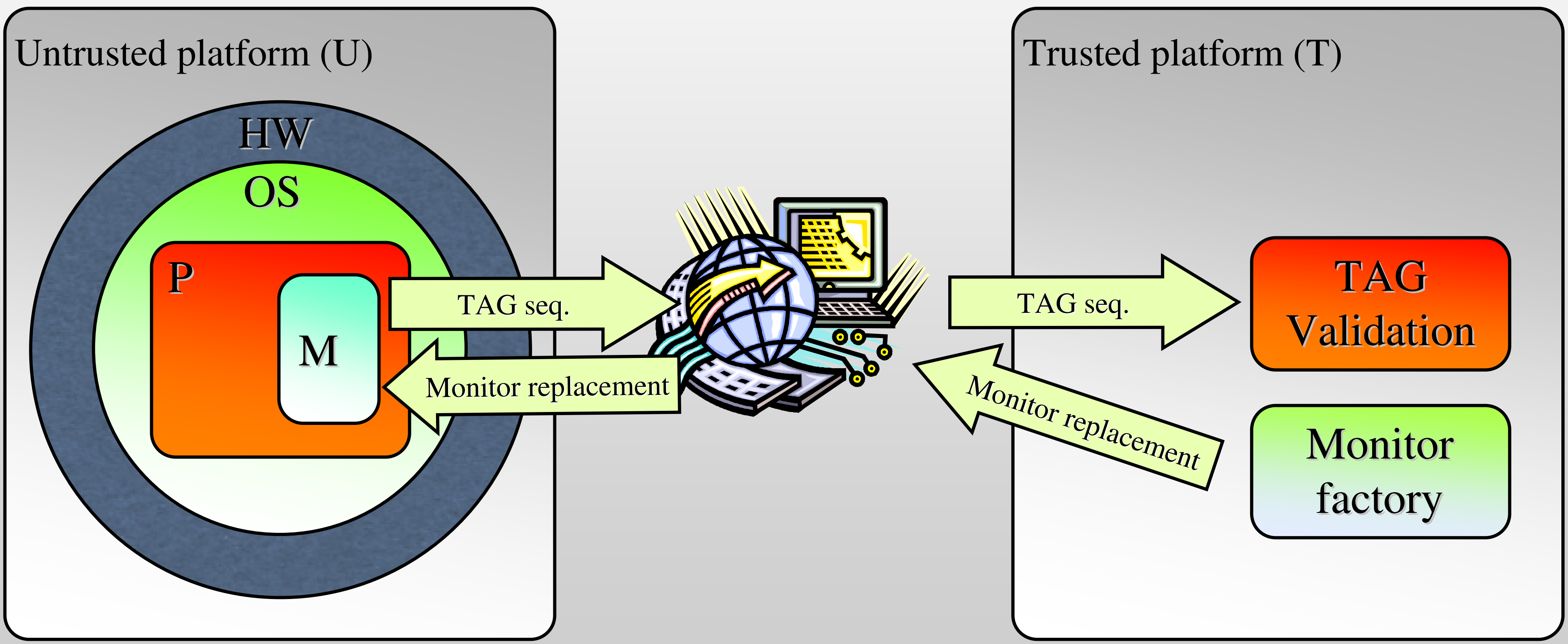
T2.1

Trust model

- Definition of the trust model for software only remote entrusting
- The output of this task is the deliverable D2.1:
  - Trust model and assumption for software based TR methods

T2.1

Trust model



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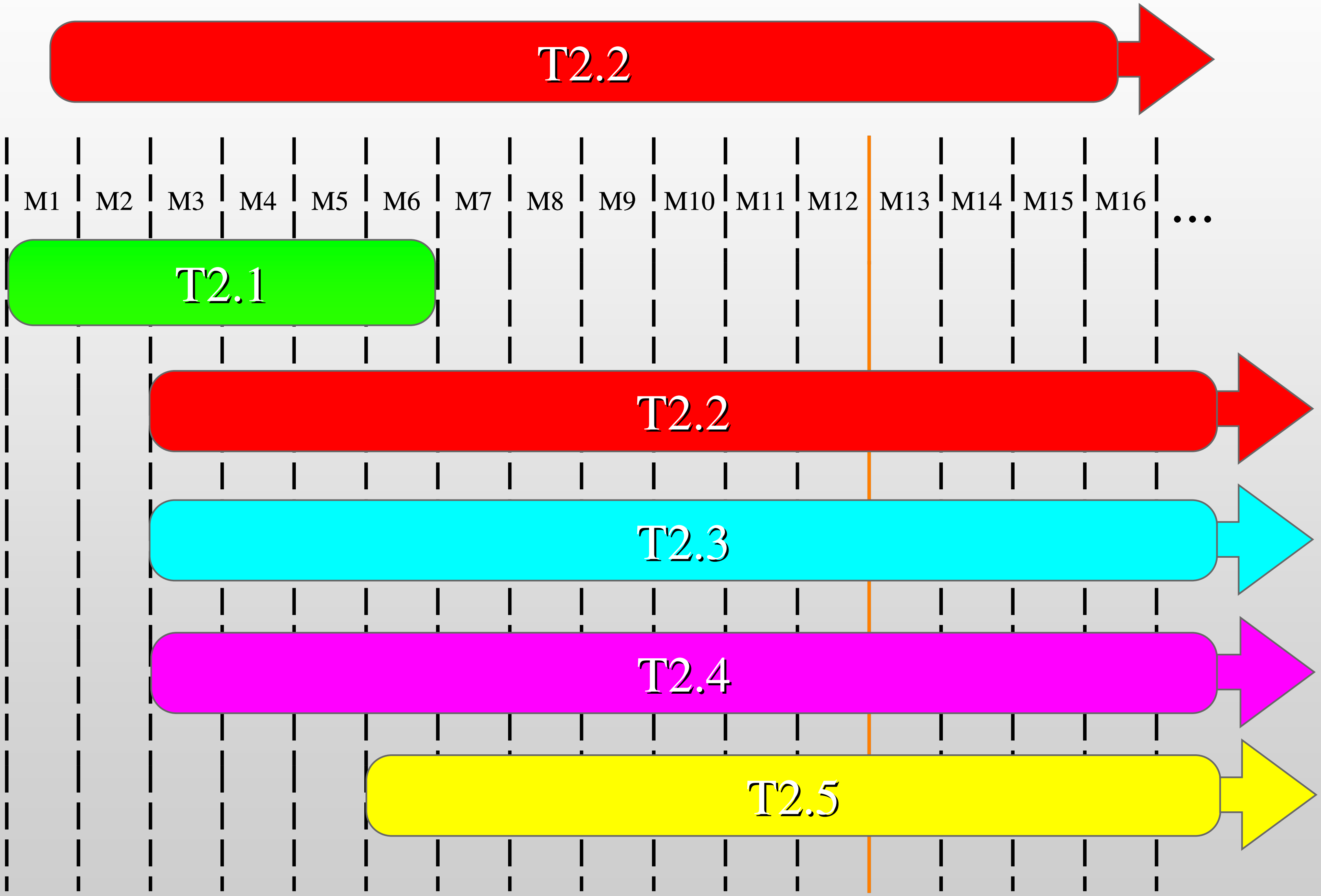
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T2.2

Secure interlocking and authenticity checking

- Definition of software techniques to:
  - Securely combine the program P and the monitor M
  - Protect the authenticity of code and data of P

Invariants Monitoring (POLITO)

- A program invariant is a property that is true at a particular program execution point
- Invariant monitoring aims at detecting attacks to the state of a program P by continuously checking dynamically inferred invariants

T2.2

Invariants Monitoring (POLITO)

- Invariants monitoring workflow
  - Invariants definition (available tools: DAIKON by Michael D. Ernst)
  - Selection of the set I’ of relevant invariants to protect a subset S’ of the state of P

How to select S’ and I’ still an open challenge?

T2.2

Invariants Monitoring (POLITO)

- Definition of a monitor M able to periodically send information about S’ to T
  - T verifies if the selected list of invariants I’ is always respected
  - Any violation is detected as an attack

- Invariants monitoring is not 100% secure
- A prototype C++ application performing strings elaboration is available

Barrier slicing (UNITN)

- Aims at protecting the state of P by moving part of its code from U to T
- It presents an alternative architecture w.r.t. the presented trust model
- Trade-off between security and performance

Barrier slicing (UNITN)

- A set S of variables to protect is removed U
- Program slicing: the (executable) slice of P responsible of the variables in S is moved to T

```
time2 = System.currentTimeMillis();
double delta = speed * (time2 - time);
x = x + delta * cos(direction);
y = y + delta * sin(direction);
Server.sendPosition(x,y);
if (track.isInBox(x, y)){
     gas = maxGas;
     lastFuel = time2;
}
else {
     gas = maxGas - (int) (time2-lastFuel);
     if (gas < 0) {
            gas = 0;
            if (speed > maxSpeed /10)
                   speed = maxSpeed /10;
            else if (speed < minSpeed/10)
                   speed = minSpeed/10;
     }
}
time = time2;
```

Barrier slicing (UNITN)

- Untrusted platform (U)
  - Use of variables in S replaced by queries and synchronization statements to T
- Trusted platform (T)
  - A barrier slicing running for each untrusted platform
  - Query and synchronization statements managed for each untrusted platform

Barrier slicing (UNITN)

- Example: barrier slice implemented on a simple car race game written in JAVA
- A complete description of the approach published
  - Mariano Ceccato, Mila Dalla Preda, Jasvir Nagra, Christian Collberg, Paolo Tonella, Barrier Slicing for Remote Software Trusting, 7th IEEE International Working Conference on Source Code Analysis and Manipulation
  - Jasvir Nagra, Mariano Ceccato and Paolo Tonella, “Distributing Trust Verification to Increase Application Performance”, in PDP2008, February 13-15, 2008, Toulose, France

White-Box Remote Procedure Call - WBRPC (UNITN, KUL)

- The name RPC implies the ability of a trusted platform T to execute an arbitrary program P on an untrusted platform U
  - In collaboration with Prof. Amir HERZBERG
- The key idea is the use of an **O**bfuscated **V**irtual **M**achine (OVM)

White-Box Remote Procedure Call - WBRPC (UNITN, KUL)

- WBRPC workflow
  - P is encrypted by T to get E(P)
  - E(P) and the inputs a are sent to U for execution under OVM

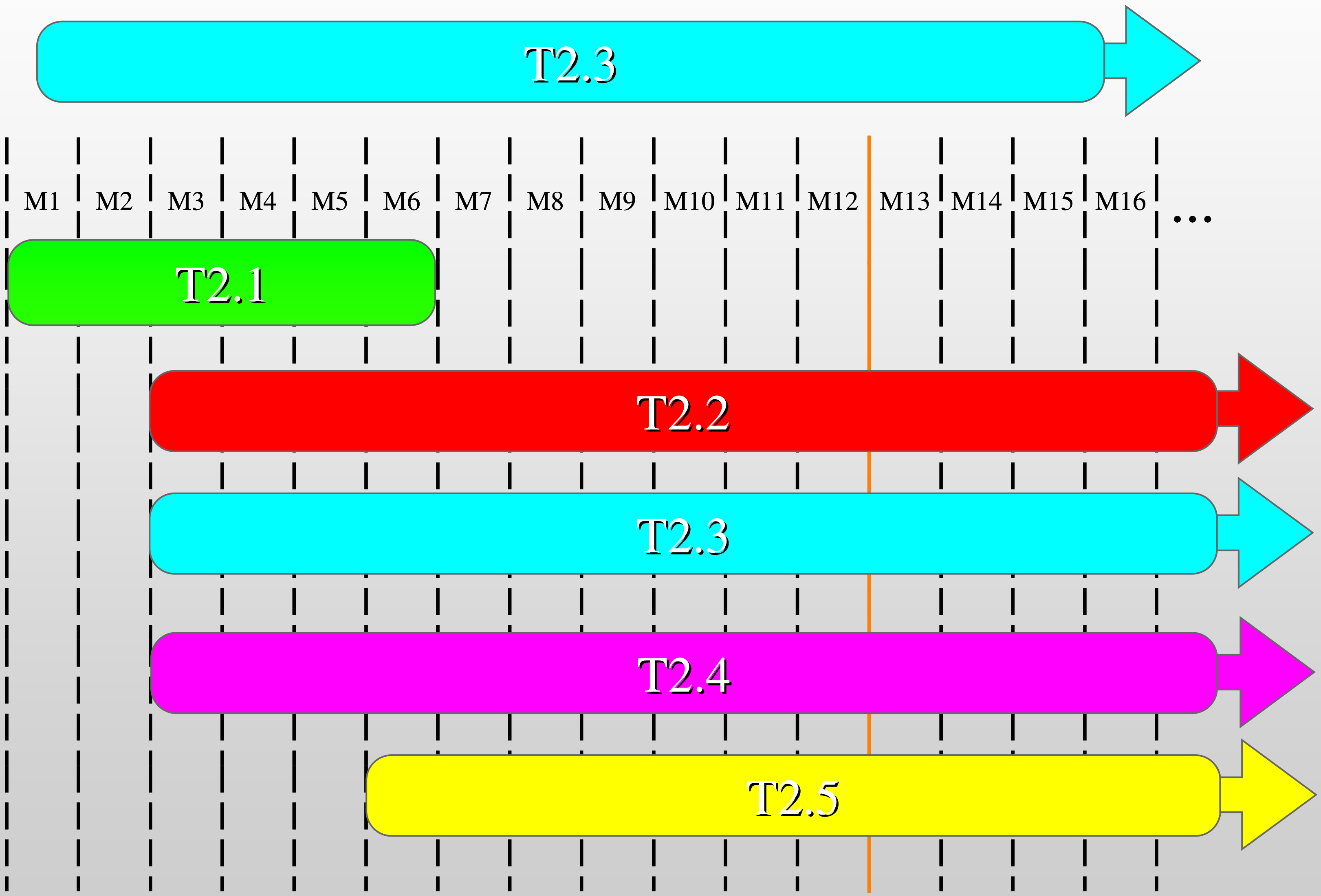
White-Box Remote Procedure Call - WBRPC (UNITN, KUL)

- OWM performs the following tasks:
  - Computes $P = D(E(P))$
  - Computes $y = P(a)$
  - Computes $z = E(y)$
  - Sends z to T
- T has the decryption key and computes $y = P(a) = D(z)$

White-Box Remote Procedure Call - WBRPC (UNITN, KUL)

- Under reasonable definition of obfuscator, we can show that OVM provides confidentiality of programs and integrity of execution of program

Tasks



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T2.3
T2.4
T2.5

T2.3

Dynamic replacement for increased tamper resistance

- Investigation of innovative methods exploiting the "time dimension" to increase overall tamper resistance of M
- The research activities of this task contribute to the deliverable D2.2:
  - Methods to dynamically replace the secure software module and to securely interlock applications with secure software modules

Dynamic replacement for increased tamper resistance

- Current (software-based) techniques co-bundle monitoring code with application code:
  - Position and behavior are hidden
- Threat (well-financed skilled attacker)
  - The user has full access on U and can exploit any type of reverse engineering facilities to break the monitoring code

Dynamic replacement for increased tamper resistance

- Continuos replacement of M
  - Selected software component and parameters of M are continuously replaced to make reverse engineering costs too high
- Dynamic replacement requires:
  - A mobility infrastructure
  - A binding support

Profiling Interfaces

(POLITO)

- MONO
  - C# on Linux
  - Interlocking and mobility from scratch
- JVMTI (profiling interface of JVM) JAVA on both Windows and Linux
  - Similar to MONO
  - Portable on any operating system
- Chat client prototype available

Aspect Oriented Programming
(POLITO)

- Prose (dynamic AOP tool)
  - JAVA based
  - Built-in mobility
  - Coarse-grain granularity for checking
- Chat client prototype available

Mutant C/C++ (POLITO)

- Uses self-modifying (mutant) code to implement the mobility infrastructure and the binding support
  - Native C/C++ code
  - High complexity (no built-in support for mobility)
  - Successfully applied on a small VNC client but a complete working prototype is still under construction

Tasks


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T2.5

Increased reverse engineering complexity for software protection

- This task addresses the challenging problem of pure software methods to protect the monitor M from tampering
  - The module behavior must be hidden to avoid trivial reverse engineering
  - Secret data inside the module (e.g., encryption keys) must be hidden in order to be not easily spotted

Obfuscation of Java byte code

(GEM)

- Use case definition in GEM context
  - Protect the secure link between an agent and a server
  - Avoid software modification
  - IP protection
  - Security of embedded software in PC based simulator

Obfuscation of Java byte code

(GEM)

- Classification of obfuscation transformation
  - Layout obfuscation
    - Remove debug information
    - Change identifier names
  - Data obfuscation
    - Change the way data is stored or encoded in the program

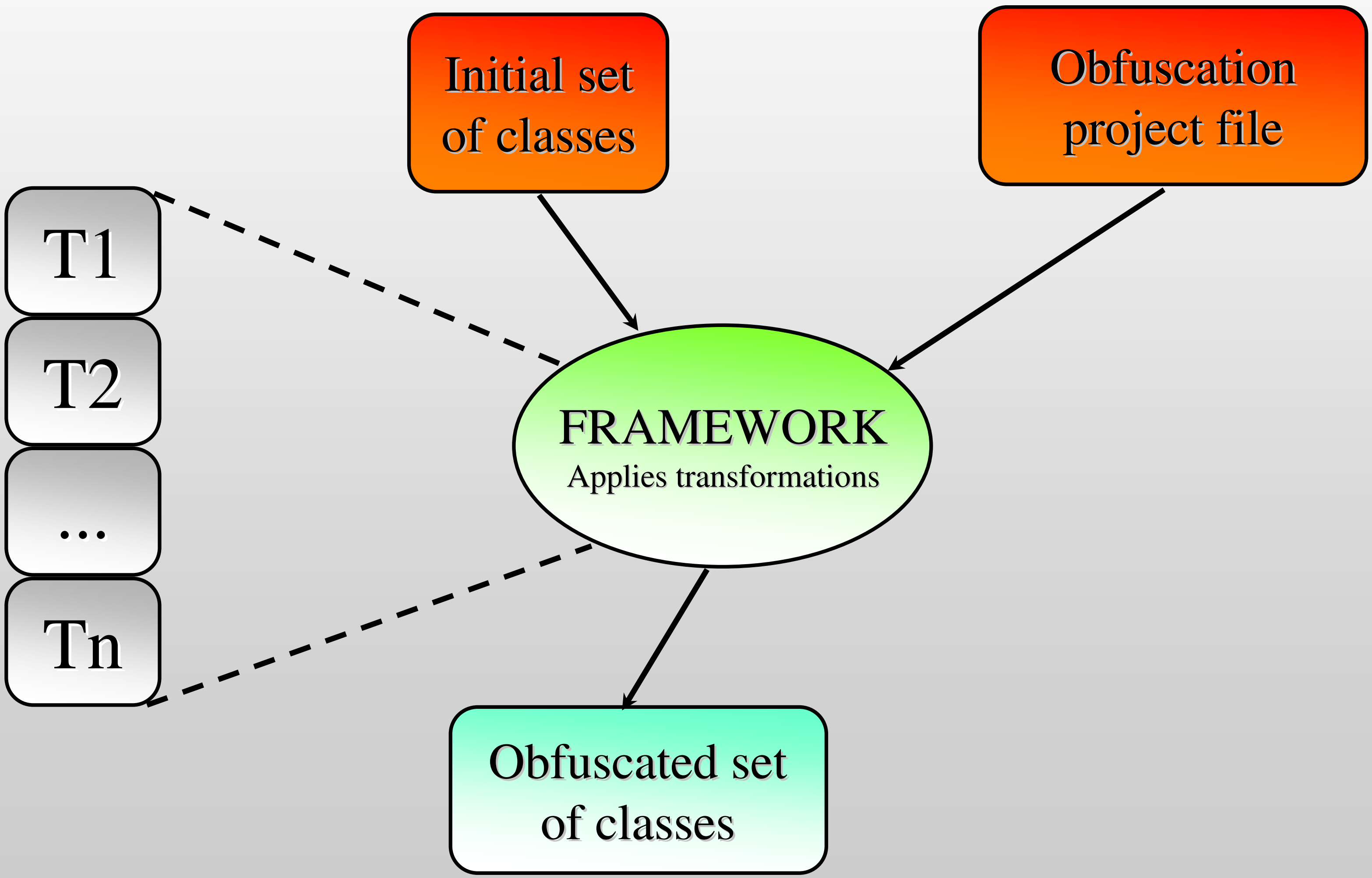
Obfuscation of Java byte code

(GEM)

- Control flow obfuscation
  - Change the way the program runs
- Preventive obfuscation
  - Try to find weakness in current de-obfuscation / decompilers to make them crash

Obfuscation of Java byte code

(GEM)



Crypto guards (KUL)

- A tamper resistance technique, in which code in an executable is encrypted
  - Guards are interleaved with the original application code
  - They create web of code dependencies
  - Decryption of code depends on other code

Crypto guards (KUL)

- During the execution of a program crypto guards make sure that:
  - The correct block of code is decrypted end executed
  - The block of code is encrypted back after the execution

C CFG flattening with TxL(KUL)

- Control Flow Graph (CFG) flattening aims at breaking down the structure of a program
  - The execution order of basic blocks is unknown (statically)
  - Dynamic analysis reveals order (if good coverage)

C CFG flattening with TxL(KUL)

- TxL: Turing eXtender Language
  - Suitable for source-to-source transformations
  - Transforms parse tree (different CFG)
- Control statements are removed form the program and transformed into a single switch-case statement

Snippets (KUL)

- Sequences of assembly inserted in assembly code after compilation (before linking):
  - They affect addresses and thus thwart offset-based cracks
  - They can break or duplicate patterns making pattern based cracks fail

Snippets (KUL)

- Our inserted snippets mostly consist of redundant code
  - Code that gets executed but does not affect the overall program behavior
- It is not trivial for compaction tools to remove all snippets completely

White-Box Cryptography(KUL)

- "Hide secret keys in software implementations of cryptographic algorithms (e.g., AES)"
  - Study of existing techniques
  - Research towards the construction of secure basic blocks and secure implementations
  - Development of a Theoretical Model

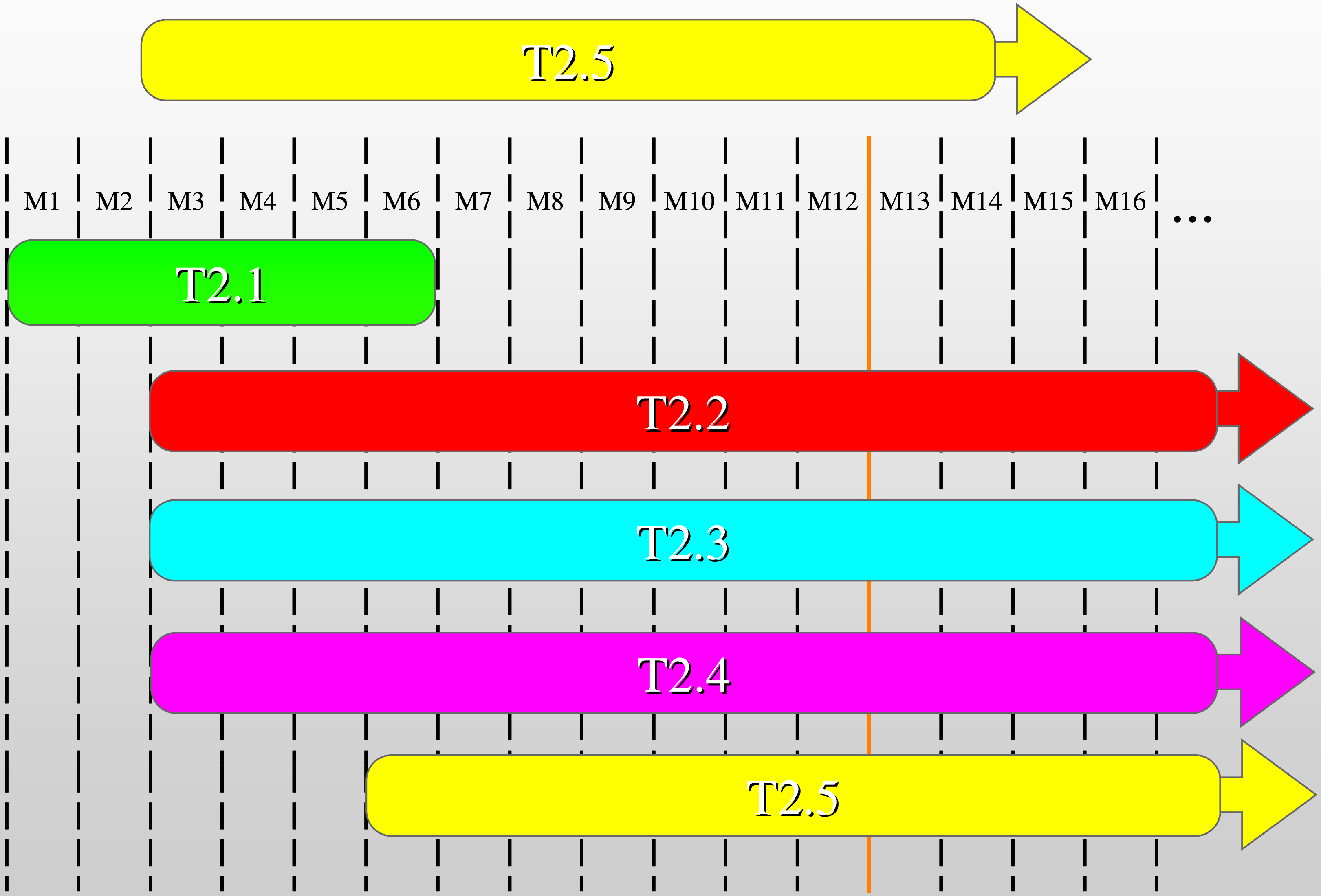
White-Box Cryptography (KUL)

- Publication of cryptanalysis of White-Box DES Implementations
  - Brecht Wyseur, and Wil Michiels, and Paul Gorissen, and Bart Preneel, "*Cryptanalysis of White-Box DES Implementations with Arbitrary External Encodings*", in Selected Areas of Cryptography, SAC 2007, August 16-17, Ottawa, Canada

Implementation (KUL)

- A real obfuscator
  - C source code to obfuscated C binary
  - Implemented techniques:
    - TXL transformations library (control flow graph flattening)
    - White-Box DES library
  - Future extensions:
    - Crypto guards (source -> binary)
    - Snippets (binary -> binary)

Tasks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T2.5

Design of entrusting protocol

- This task will cover the cryptographic and synchronization concerns of the communication protocol employed between the monitor and the trusted platform

T2.5

Design of entrusting protocol (SPIIRAS)

- Analysis of data flows to be involved in remote entrusting mechanisms
  - Analysis of structure of transmitted data, quantitative and time intensity assessments of data
- Development of target protocol security requirements

T2.5

Design of entrusting protocol (SPIIRAS)

- Analysis of existent network and cryptographic protocols
- Definition of network protocol facilities to fulfill the target protocol security requirements
- Analysis of formal methods for design of entrusting protocol

Future activities

- Assessment of the proposed software techniques (T2.2, T2.3 and T2.4) and investigation of alternative architectures
- Definition and implementation of a Monitor Factory (T2.3)
- Focus on the trust protocol design (T2.5)
- Early specification of the proof of concept for software only remote entrusting (T2.6)