COSME: a framework for agile manufacturing systems

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COSME is a software platform which allows to design, build and execute distributed control applications. COSME was initially born under the requirements of the company TUROMAS, a glass cutting and handling machine tools manufacturer for over 20 years (www.turomas.com). It is the platform TUROMAS is using for the development of their new generation of products.

COSME is still not a full implementation of the IEC 61499 standard, although it uses some of its concepts: (a) Component based programming (FB-Types) (b) Applications created composing FB networks (c) Distributed system (FB networks can be spread across various controllers), and (d) Reconfigurability (FBs can be substituted from the FB network on the fly), so, COSME allows to develop control software for agile manufacturing.

On the other hand, its main defining characteristics are the following: (a) Predefined events in all FB-types. The COSME execution model assumes the existence of those predefined events, and ensures the code execution in a sequential fashion, which gives, as a result, a predictable and reproducible behavior, in a simpler and scalable implementation. (b) Predefined communication types allow designers to avoid dealing with the communication details. As a result, connections across controllers become much more transparent and straightforward.

COSME is still under development and it is not intended to become a commercial product. It will be released as open source software. COSME fits well to machine tools design requirements but it is flexible enough to be used in other application domains.

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Motivation

- TUROMAS: 20 years of experience
- Outdated technology :
  - MS-DOS, no Network, obsolete GUI, no USB, …
  - "*Guru*" multifaceted engineer needed
- Needs detected:
  - Open+Standard platforms: RTOS, Network, Windows-like GUI
  - ↓ development costs
  - ↓ guru dependance
  - ↑ customer perceived quality
  - Add non-functional requirements
    - Integration with Enterprise Information Systems (MES, ERP…)
    - Preventive/Predictive maintenance, Fault Management
- Got interested in:
  - Component orientation
  - Reusability & reconfigurability ➔ **Agile manufacturing**
  - Distributed control
    - ➔ From **machine tools** to **manufacturing cell/lines**

Technologies considered for the new generation of products

- PLCs with IEC 61131 (not enough)
- **IEC 61499 looks the obvious choice**
  - **Commodity** IEC 61499 PLCs?: still not
- Go ahead with COSME
  - Build our own “thing” to fit our needs
  - IEC 61499 looks great, but:
    - Full implementation is hard
    - Didn’t need a full implementation
    - ➔ **COSME is a partial implementation of IEC 61499**

A success case

Requeriments

- Cutting glass machine tools / machining lines
  - Numeric control
    - Up to 11 axes, 1 ms cycle time, better than 1mm precision, accelerations up to 22m/s^2
  - PLC like
    - About 50 automatic sequences
  - I/O field buses
  - Integration with information systems
  - Value added functionalities
  - Distributed control
    - Loose coupling between line elements: cutting tables, loaders, storages, …

COSME particularities

	IEC 61499	IEC 61499 COSME approach
FB model	Event driven. Designers define event and data I/O, and ECC	Event driven. Predefined event I/O and ECC (normal/failure operation, initialization, etc.). Designers define data I/O
Execution models	FB invocation: Sequential or cyclic; Execution contexts: FB, resource or event chain; NPMTR (FBRT); parallel	Daisy chain (based on event chain model)
Distributed FBN	Designers must deal with the details (e.g. SIFB, FBN modifications caused by synchronization issues)	Transparent to designers (see next slide)
SFCs	Not considered	Designers can define SFCs for each FB-Type
Language	IEC 61131, Java	C (present), IEC 61131 FBD (future)
Implementation	Harder	Simpler
Scalabity	Application dependent	Good
Scope domain	General	Limited

Communicating machine tools

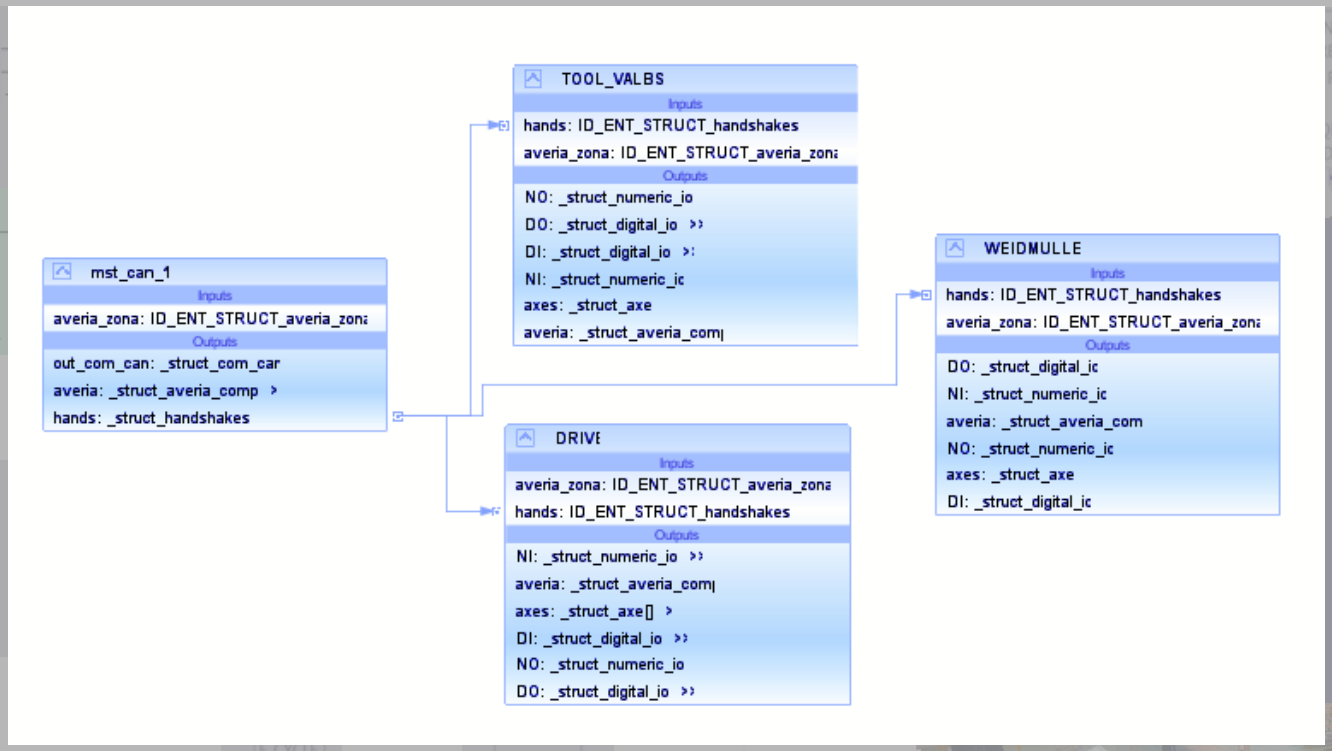
Comm. Types	Typical latency	Exec. model	Reliabilibty	Amount data	Example
Applicati control					
Process c					
Process comman					
Process synchron					
HMI					
Aplicatio management					
Production data management	Few seconds	Cyclic-driven	Yes	MBytes	Communication with Manufacturing Execution Systems (MES)

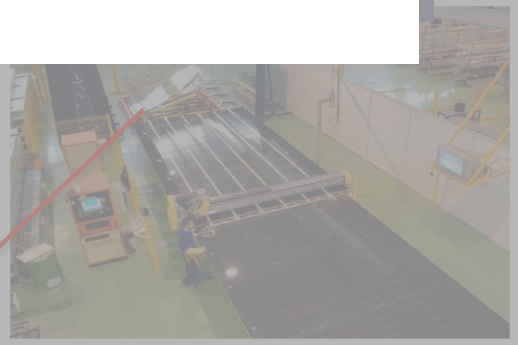
Communication type	COSME Daisy chain	Remarks
Application control	**COLD_INIT, WARM_INIT, FINALIZE, FAILURE, FAILURE RECOVERY**	No associated data
Process control	**NORMAL_RT, EXT_EVENT**	Associated data
Process command & synchronization Data management	**NORMAL_NRT, BACKGROUND, BACKGROUND_REQ**	Associated data

COSME workflow

1. Create FB-Types, when necessary
   - Define data input/outputs, internal variables
   - Define actions (normal/failure operation, initialization, etc.)
   - Define SFCs
2. Create the FB network
   - Instantiate FB-Types
   - Define connections only between data inputs and outputs (not necessary for events)
   - Define FBs execution order
3. Generate code, compile and deploy
4. Debug the application with provided tools

A simplified COSME application





I/O

Application control

Process synchronization

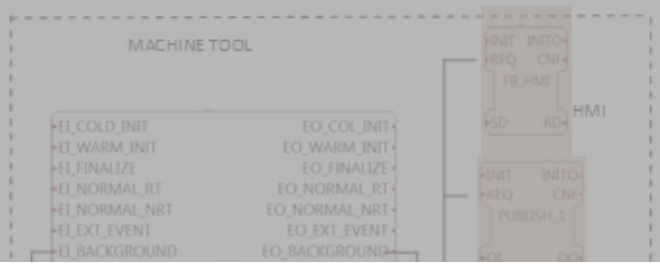
Sheet Loader

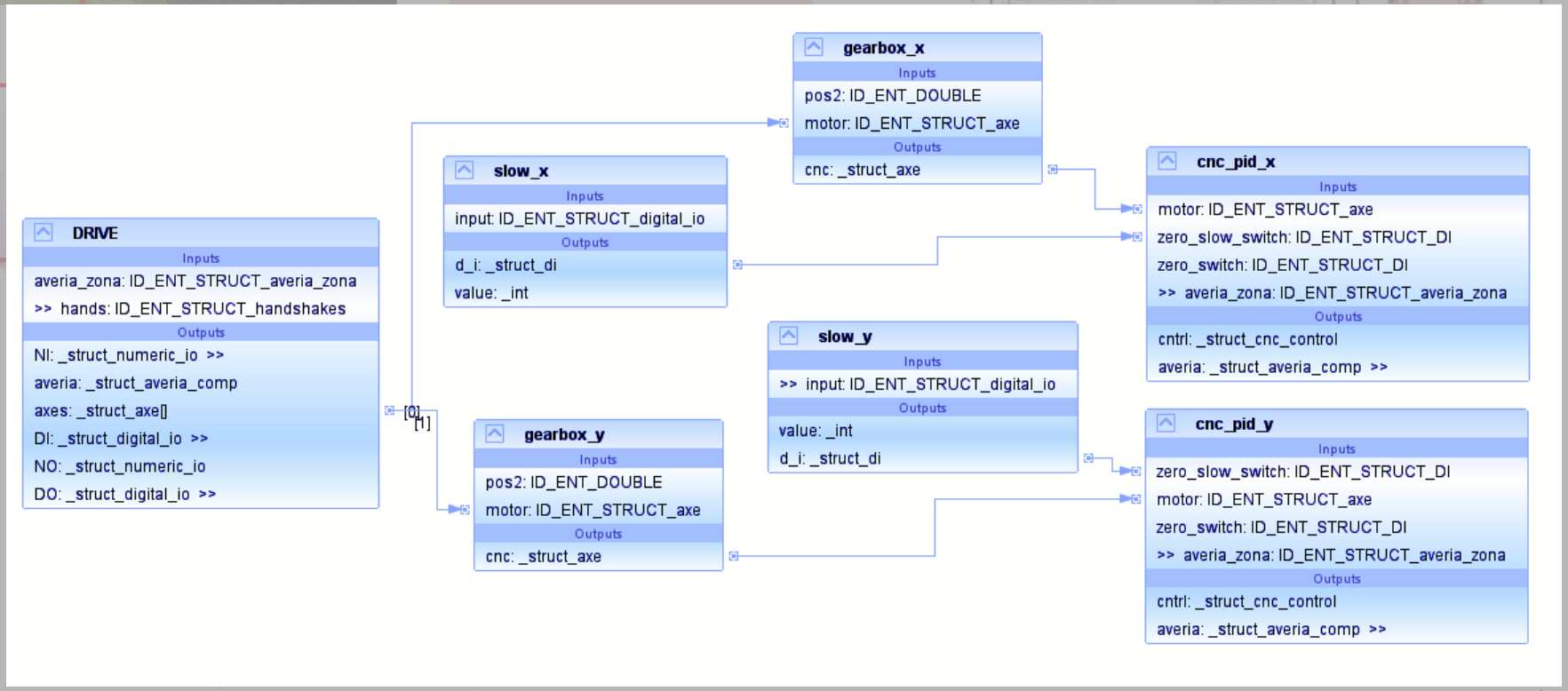
A simplified COSME application

I/O

Application control

Process synchronization/HMI

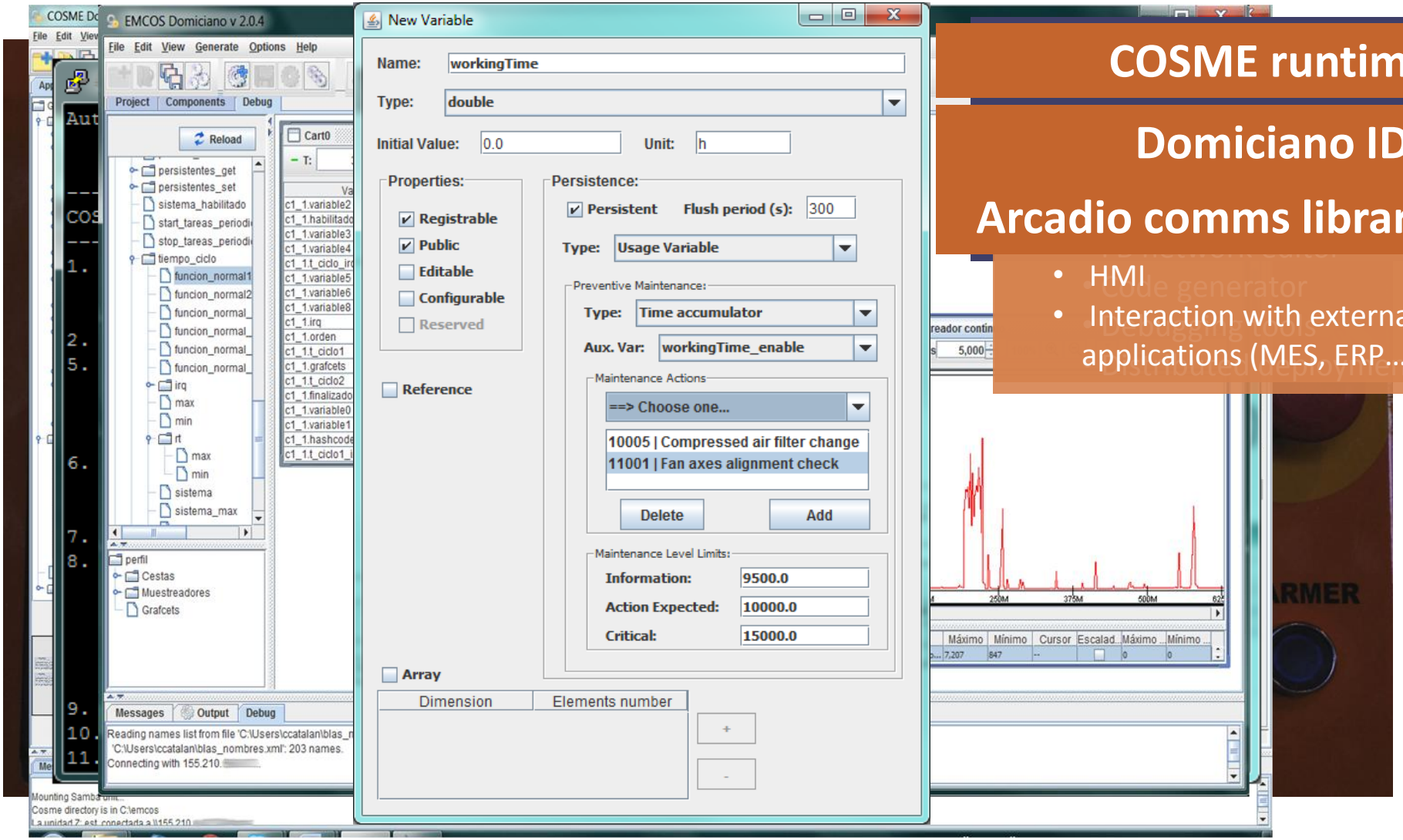




A real COSME application

- Complexity
  - ≈ 35 FB-types, 200 instances
  - ≈ 70 SFCs
  - 2 CANopen field bus
  - ≈ 128 digital I/O
  - 11 encoders
  - 1 ms cycle time (RT), 20 ms cycle time (distributed non-RT)
  - Windows-like HMI, integration with MES
- Running on
  - 1 B&R AutomationPC 620 (celeron type industrial PC)
  - RTAI (Linux Real Time) + Java

The elements of the COSME framework



COSME runtime

Domiciano IDE

Arcadio comms library

- HMI
- Interaction with external applications (MES, ERP…)

Where can

- Still not for sa
- In fact
  - It will be ava
- Organizations
  - **feeding COSME with vectors to help steer its development**…
  - …are welcome

- Interested?

➔ Let's talk!

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