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CoSimA+ CO-SIMULATION ADAPTATION PLATFORM

COUPLING HETEROGENEOUS COMPUTATIONAL CODES IN A DISTRIBUTED SIMULATION ENVIRONMENT FEATURING HUMAN-CENTERED INDOOR THERMAL AND AIR QUALITY PERFORMANCE PREDICTION

When modeling human thermoregulation and predicting thermal comfort sensation under realistic environmental conditions, the need for code coupling is likely to arise. In order to address transient and asymmetric thermal conditions, a variety of computational codes has to be integrated properly. This is due to the intrinsic complexity of the given multi-physics problem domain but also the lack of integrated software solutions already addressing specific co-simulation demands.

CoSimA+ is developed for coupling numerical sub-models and experimental tools such as sensor hardware in a distributed simulation platform to support human-centered indoor thermal and air quality performance prediction. It enables the adaptation of proprietary models, legacy software and third party codes. It provides a set of basic built-in functional components, but it also aims to support arbitrary modular extensions in order to customize specific co-simulation scenarios. CoSimA+ has two main aspects:

- *CoSimA+Middleware* provides the communication, configuration, monitoring and control infrastructure which constitutes the simulation runtime-environment.

- *CoSimA+Framework* comprises a documented library of classes and interfaces, including a developer guideline which supports the adaptation and integration of arbitrary simulation codes.

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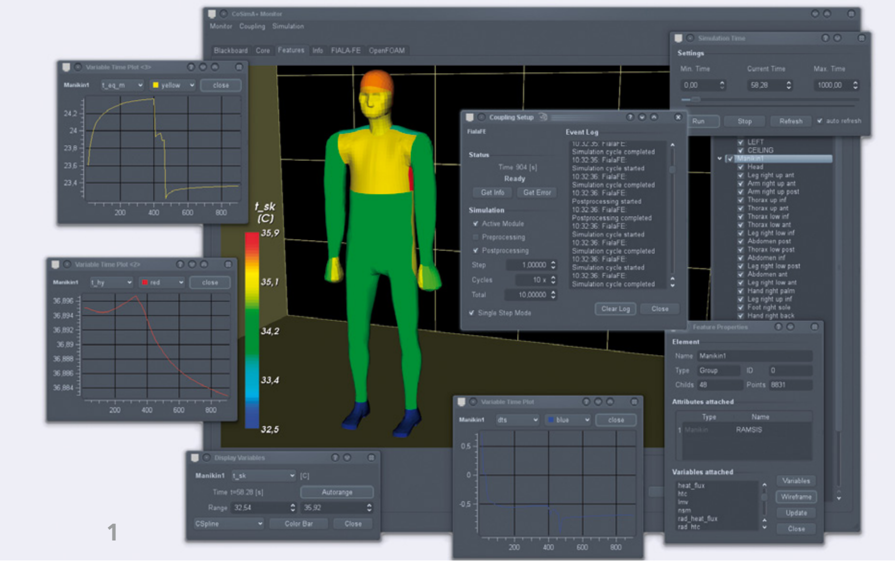

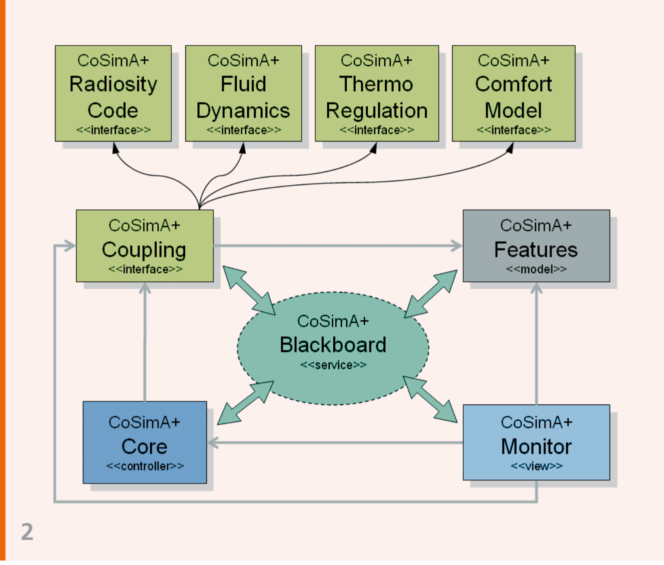

CoSimA+MIDDLEWARE

Data Exchange
The middleware ensures reliable data exchange between Coupling Modules by providing synchronous and asynchronous communication. The implemented client-server model enables synchronous method invocation of remote objects, similar to Remote Procedure Calls (RPC). An event and messaging service provides means to broadcast predefined or user defined messages on a blackboard.

Scene Description
The global scene model is incorporated in the Features Database (DB). Scene objects are hierachically grouped and structured, including attached variables and attributes. Mesh information used for numerical simulation is converted in order to preserve the inherent scene topology. All elements are stored in a mesh-based surface representation, which is segmented into so-called patches.

Data Visualization
Features are visualized in a Graphical User Interface (GUI). The Monitor allows users to navigate through the scene and to observe the current simulation state. Since the distributed co-simulation requires monitoring of particular control variables, CoSimA+ provides means to plot variables as discrete time series.

Simulation Control
As the presented coupling approach leads to a distributed multi-rate co-simulation, a central control instance is in charge of executing all models simultaneously. Each sub-model may be individually configured by setting processing options, and by further defining an individual step size which is used for striding along global simulation time. The CoSimA+ Core ensures proper activation and processing of each contributing sub-model.

System Monitoring
Sub-models are usually implemented and run as separate processes. Each sub-model can be allocated on a different node in a heterogeneous distributed platform. Thus, the middleware takes care of registration and connection of all participating modules.

CoSimA+FRAMEWORK

CoSimA+ supports user defined platform extensions. As a modular and open framework, it enhances the development of customized adapters which are able to interface with proprietary simulation codes. Any customized module must comply with a minimal set of functional and architectural requirements which are well specified and documented.

Code Adaptation
The framework provides facilities to integrate and adapt a variety of simulation codes. In order to program a valid co-simulation sub-model, the developer must adhere to predefined interfaces and procedures.

Interface Specification
First step of the development of a sub-model is the formal definition of an interface to a particular software module using an Interface Description Language (IDL). The definition is converted into code in the programming language of choice such as C++, Java, or Python. The adaptation of the sub-model shall be accordingly realized using the most appropriate programming language. In that way, CoSimA+ implements an object oriented distributed system, i. e., location, access, scaling and migration is fully transparent.

Modular Widgets
To provide an individual user interface to the custom Coupling Modules, the Monitor integrates externally developed widgets. The customized widgets are attached to the main desktop application, which makes it easy for the user to interact concurrently with other modules.

Heterogeneous Platform
Having specified the interface, the implementation can be achieved in different languages and on different computing platforms. Interaction across different types of host platforms and programming languages is transparently performed by the underlying communication engine. This includes marshalling and unmarshalling of data, and the byte ordering requirements.

1 *Screenshot of monitor application during simulation of human thermoregulation.*

2 *Overall software architecture with examplary coupling modules.*