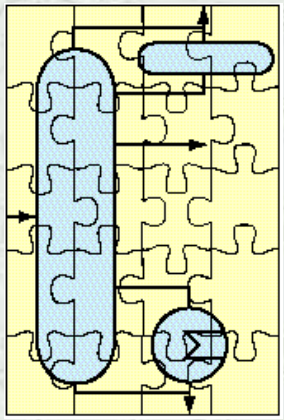

Global CAPE-OPEN

Open Architectures for Process Modelling Software

by

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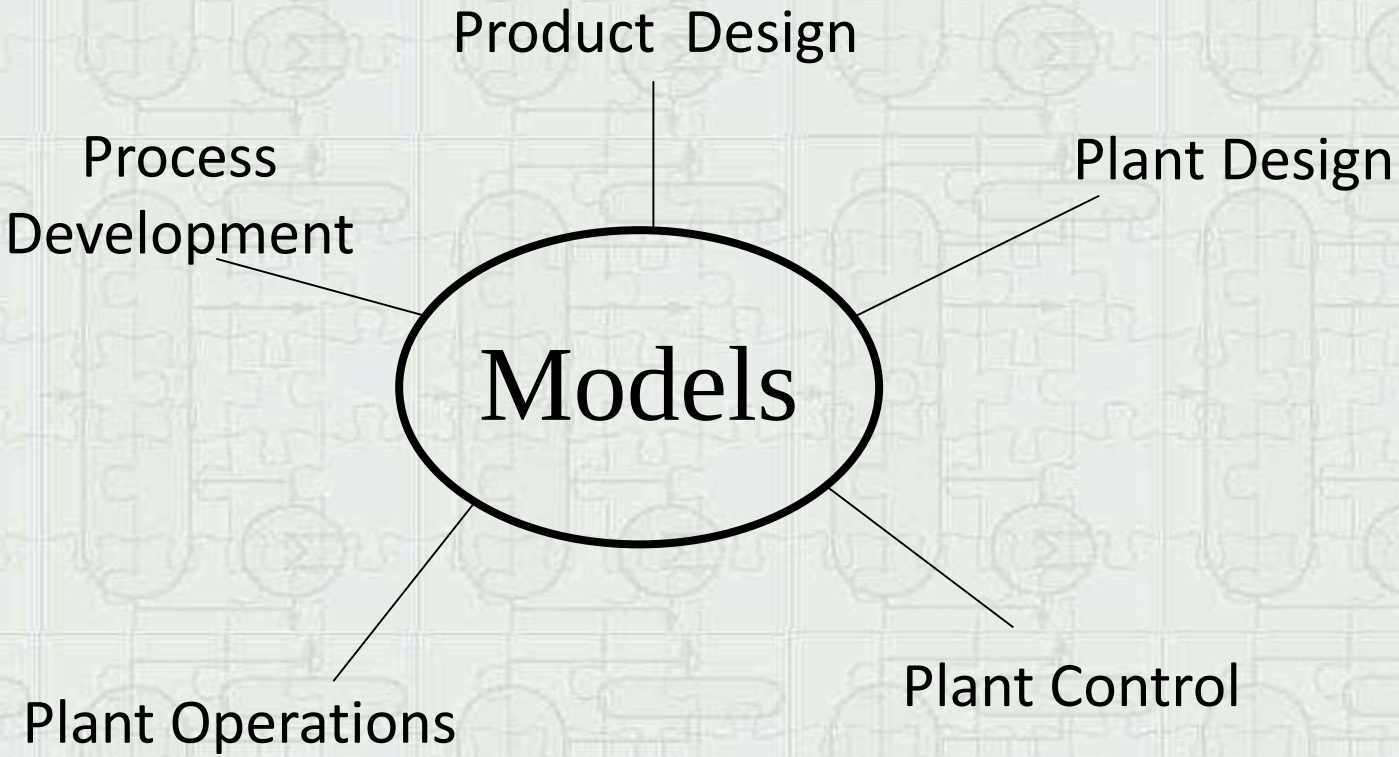
Overview

- The road to CAPE-OPEN
  - Process modelling software demand & supply
  - Process Modelling Components (PMCs) and Process Modelling Environments (PMEs)
  - Why open process modelling tools ?
- The CAPE-OPEN and Global CAPE-OPEN projects
  - Organisation
  - Objectives & scope
- Concluding remarks & future perspectives
  - Concrete achievements to date
  - The road forward for CAPE-OPEN
  - Opportunities

The road to CAPE-OPEN

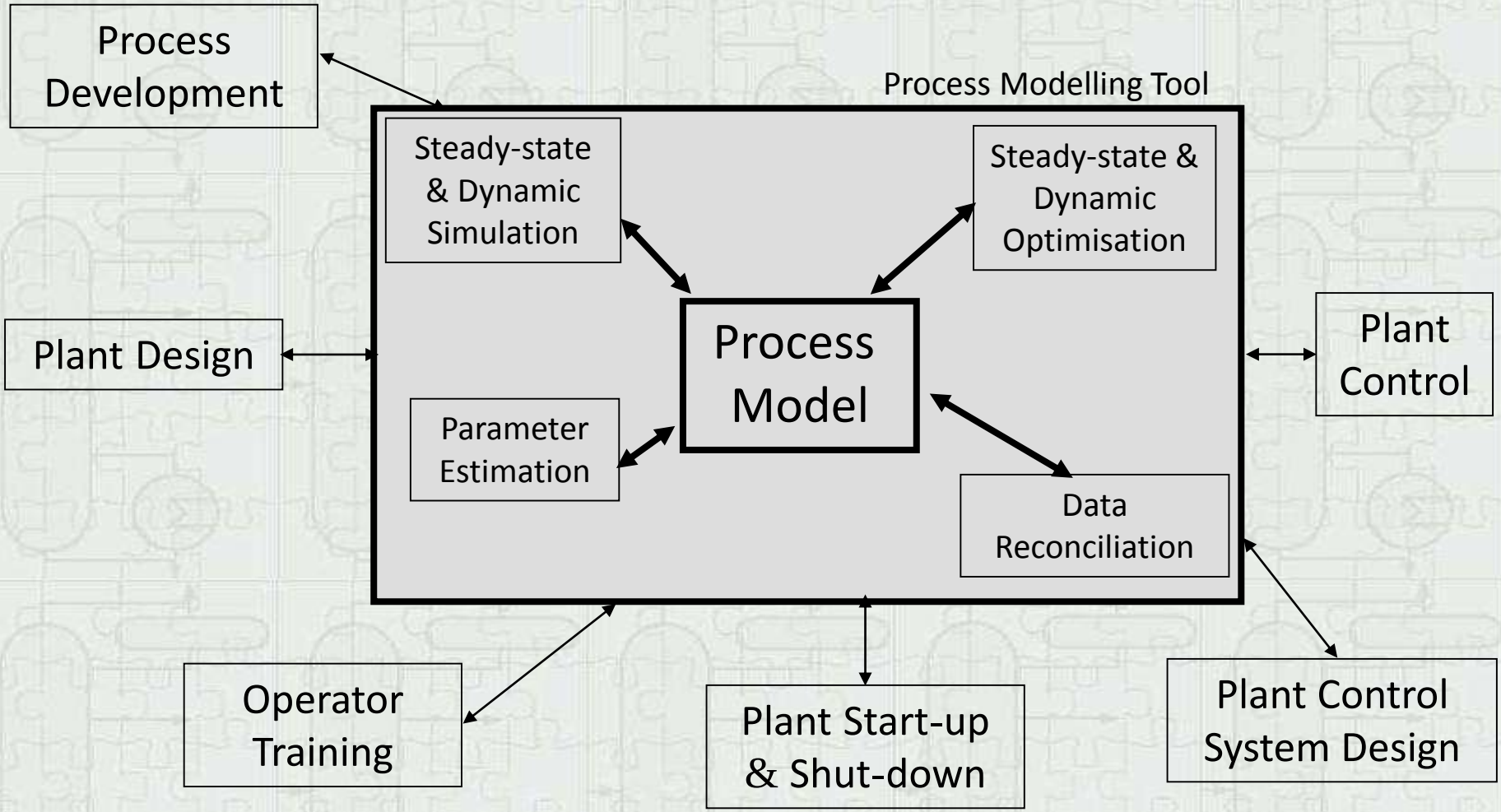
Model-centric process engineering



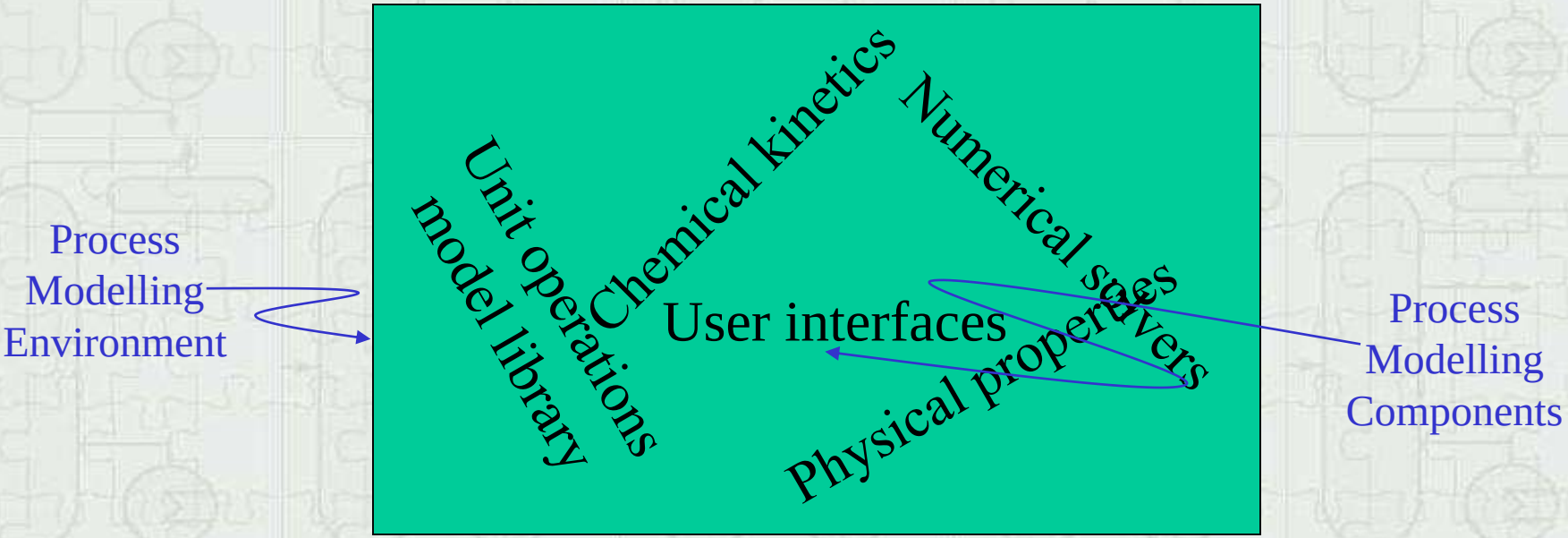
Process modelling software: demand & supply

- **Increasing usage of process models in industrial practice**
  - **process design, operation, control...**
- **Increasing supply of process modelling tools**
  - **software vendors**
  - **universities**
  - **operating companies**

General-purpose process modelling tools



The anatomy of process modelling tools – a (somewhat) confusing reality



- Many interacting components…
- …all tightly coupled with each other
- Component boundaries not always clearly delineated

Process modelling: components & environments

- **Process Modelling Components (PMCs)**
  - **well-defined pieces of software, relatively narrow function**
  - **wide range of applications**
    - **physical properties**
    - **unit operation modules**
    - **numerical solvers**
    - **. . . . . .**

Process modelling: components & environments

- **Process Modelling Components (PMCs)**
- **Process Modelling Environments (PMEs)**
  - **support construction of process model**
    - **from first-principles and/or library of unit operation models**
  - **support a number of model-based applications**
    - **simulation, optimisation, …**
  - **may make use of one or more PMCs**

Four developments over the past decade - I

- Increasing emphasis towards integrated process modelling
  - PMCs alone of limited utility
  - PMEs gaining dominant position

Four developments over the past decade - II

- Increasing emphasis towards integrated process modelling
- Adoption of generic PMEs
  - proprietary tools being replaced by outsourced PMEs
  - customisation of generic PMEs to meet specific requirements

Four developments over the past decade - III

- Increasing emphasis towards integrated process modelling
- Adoption of generic PMEs
- Limited supply of generic PMEs
  - increasingly high levels of technical complexity
  - increasing user expectations
  - increasing skill & resource requirements

Four developments over the past decade - IV

- Increasing emphasis towards integrated process modelling
- Adoption of generic PMEs
- Limited supply of generic PMEs
- Increasing range of model-based applications
  - parameter estimation
  - plant data reconciliation
  - controllability analysis
  - process safety verification
  - fault detection
  - . . . . . .

Structural Problem I

- **Good-quality PMCs increasingly available from a variety of sources…**
- **... but will be used widely only if incorporated within existing PMEs**

Structural Problem II

- A strong commercial incentive to develop and use new types of model-based applications
- …but development of underlying model is often the main bottleneck

- Many models are already available...
- …but are embedded (and well hidden!) within the existing PMEs

Key Requirements

- General, effective and efficient mechanisms for:
  - incorporating new PMCs within existing PMEs
  - making models embedded within PMEs accessible to external applications

Key Requirements can be addressed only with…

OPEN SOFTWARE ARCHITECTURES FOR PROCESS MODELLING

CAPE-OPEN & Global CAPE-OPEN

The CAPE-OPEN project

- 1 January 1997 – 30 June 1999
- Partially funded by EU Brite-EURAM programme
- Consortium structure
  - 7 operating companies
  - 4 process software companies
  - 3 universities

Consulting partner SIMSCI SIMULATION SCIENCES INC.

The Global CAPE-OPEN project

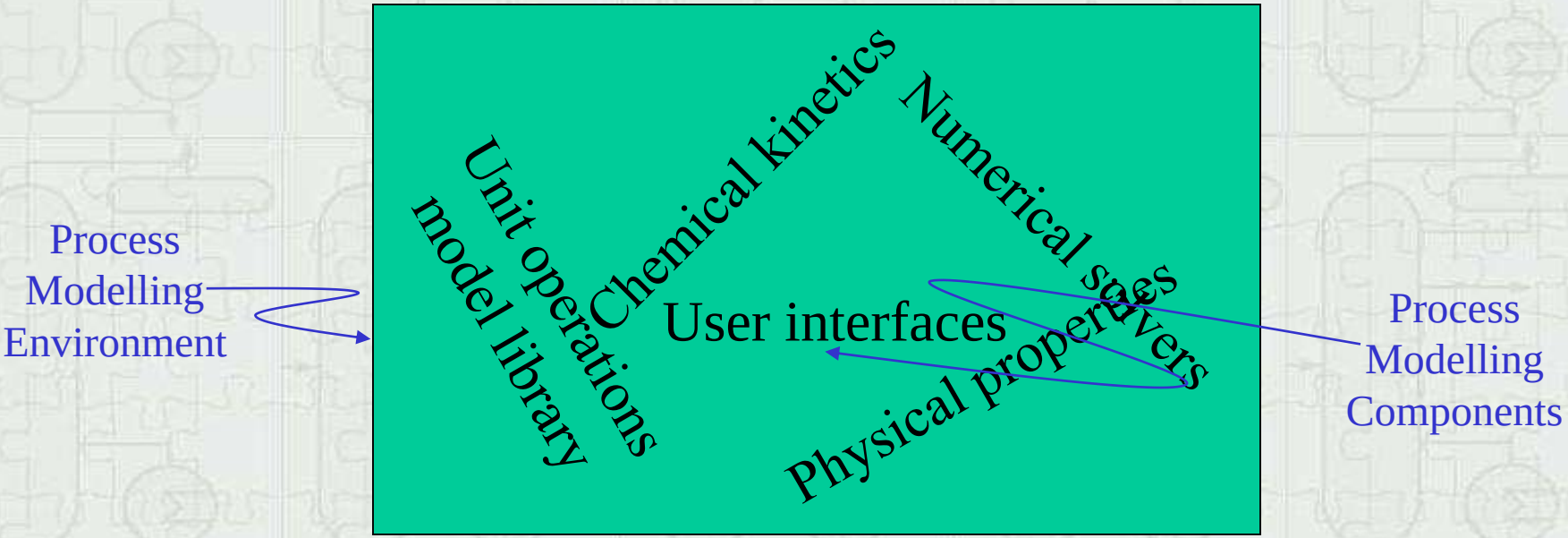
- 1 July 1999 – 31 December 2001
- Undertaken under the international Intelligent Manufacturing Systems (IMS) programme
  - European Union (including Norway)
  - Japan
  - USA
  - Canada
- Partially funded by the EU and the Japanese government

The Global CAPE-OPEN project

CAPE-OPEN & Global CAPE-OPEN vision

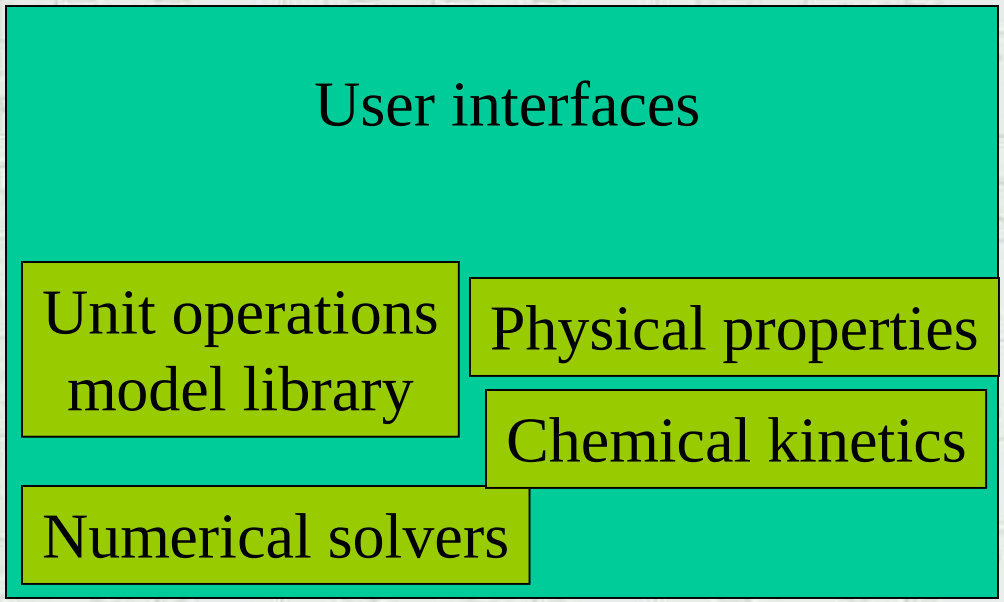
- **Complete interoperability between**
  - **Process Modelling Environments**
  - **Process Modelling Components...**
- **from diverse sources…**
- **written in diverse computer languages…**
- **implemented on diverse computer platforms...**

Where does one begin ?

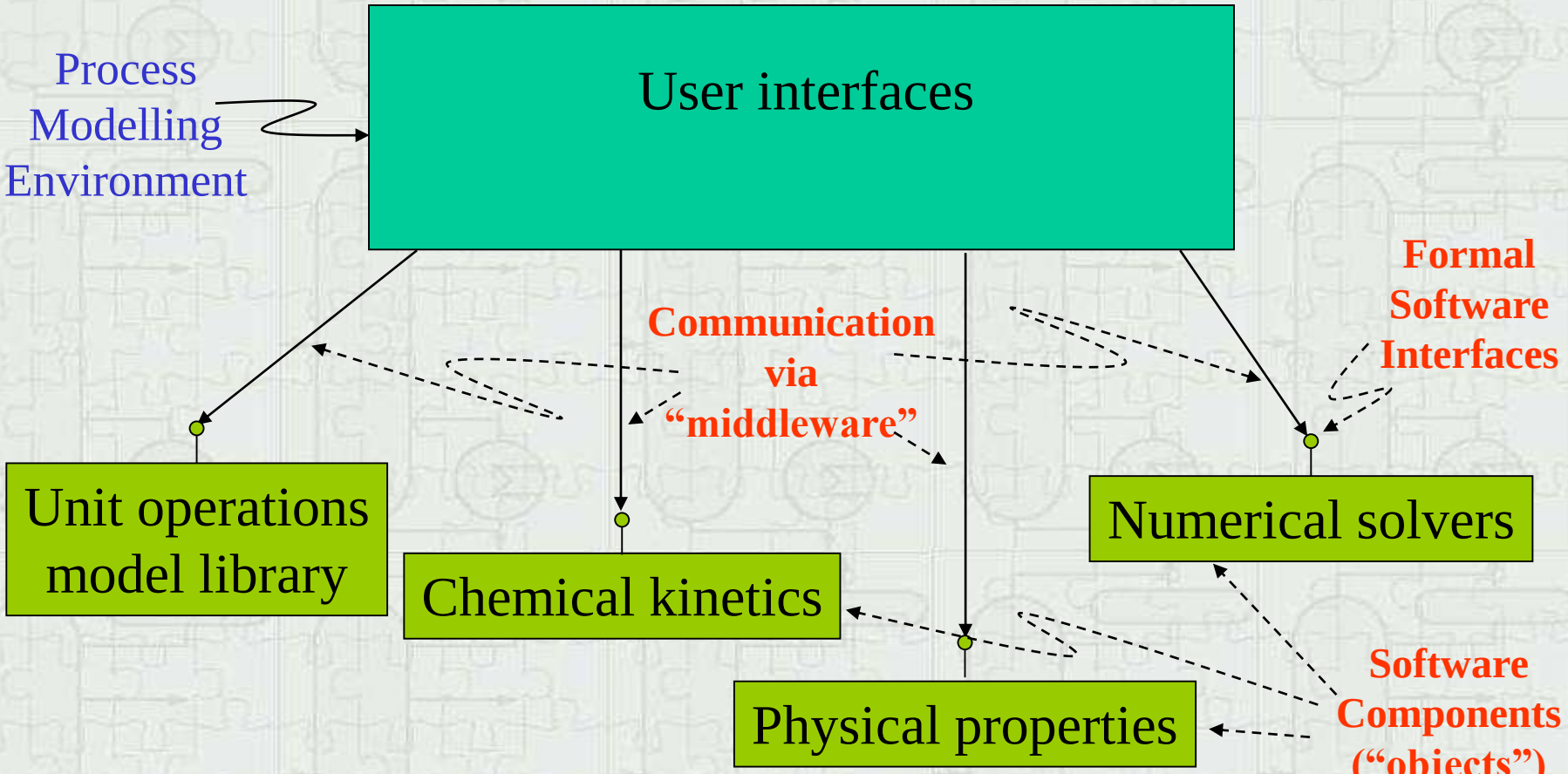


- Many interacting components…
- …all tightly coupled with each other
- Component boundaries not always clearly delineated

Clarify boundaries between key components…



…and break tool into 1 PME & multiple PMCs



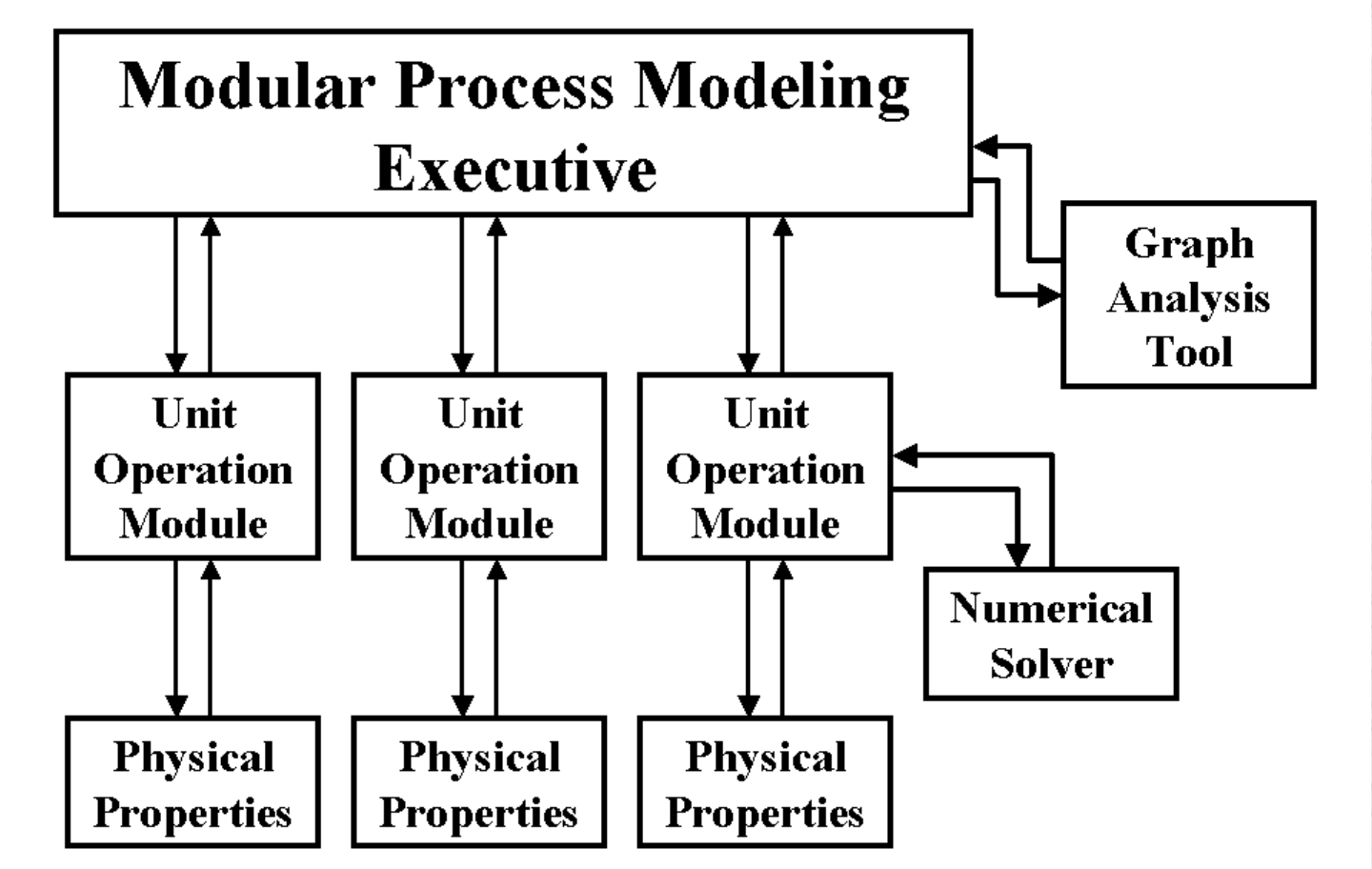
CAPE-OPEN & Global CAPE-OPEN objectives

- **Identify major classes of PMCs and define general software interfaces for them**
- **Develop & test prototype software demonstrating PMC use & benefits**
- **Promote understanding, acceptance & adoption of open software architectures**
  - **industry**
  - **process engineering software companies**
  - **academic community**

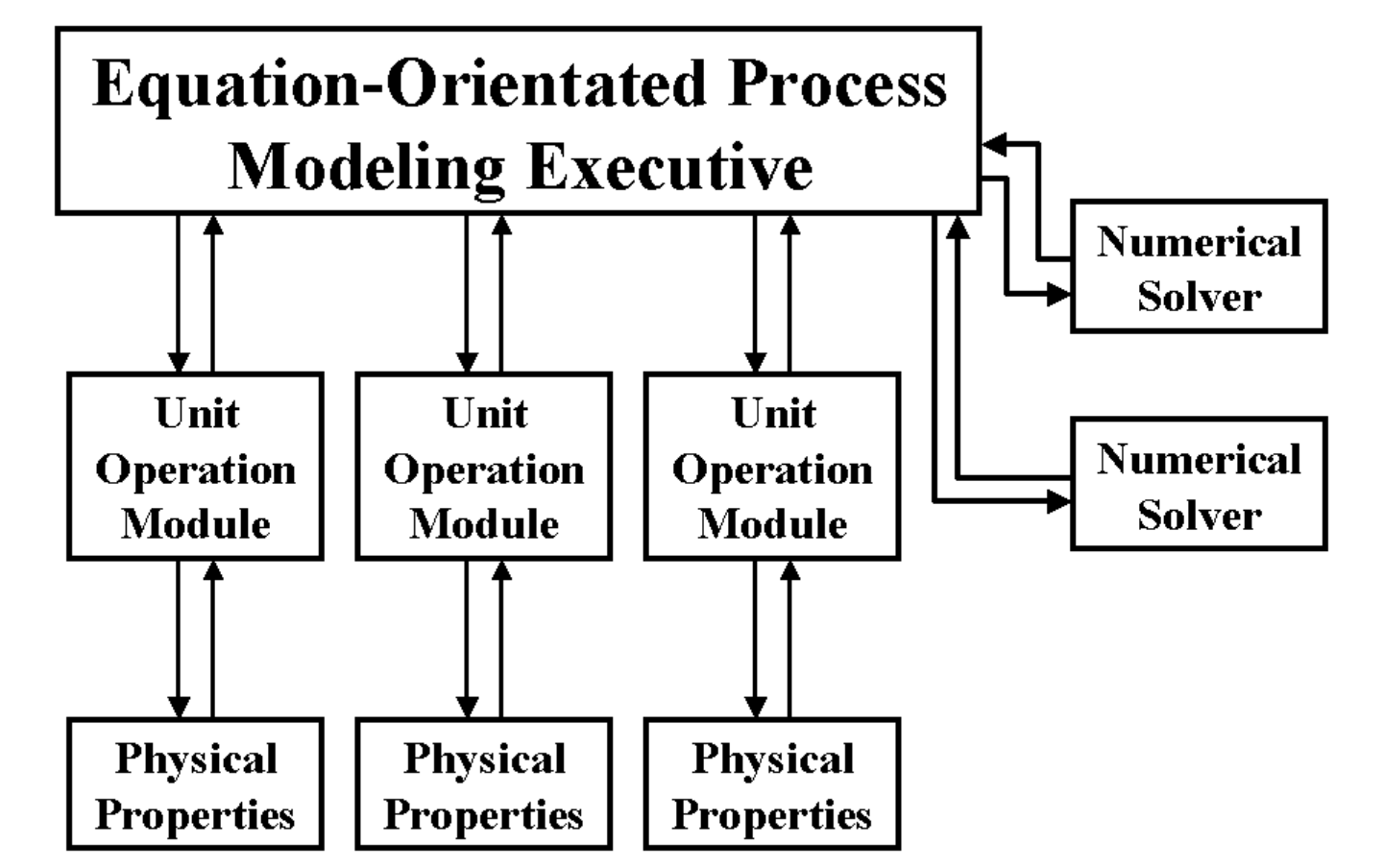
CAPE-OPEN & Global CAPE-OPEN scope

- Primarily focussed on process modelling software tools
  - but technology has applicability to other areas (e.g. supply chain optimisation)
- Both “modular” and “equation-orientated” process modelling tools
- Focus on components for
  - building the process model
    - unit operations models, physical properties, chemical kinetics
  - carrying out various activities with the process model
    - simulation, optimisation, parameter estimation

Modular Process Modelling Tool



Equation-Orientated Process Modelling Tools



CO/GCO has defined interfaces for…

- Physical property computations
  - conventional materials & electrolytes
- Physical property databanks
- Chemical kinetics computations
  - non-equilibrium & equilibrium reactions
- Unit operation modules
  - primarily for modular steady-state modelling tools
- Numerical solvers
  - solution of systems of equations
    - linear algebraic, nonlinear algebraic, differential algebraic, partial differential-algebraic
  - solution of optimisation problems
    - LP, NLP, MILP, MINLP
  - solution of parameter estimation & data reconciliation
  - graph-theoretical analysis tools

To conclude...

Some personal opinions

CO/GCO: some concrete achievements to date

- "Tried-and-tested" interface specifications for
  - physical properties
  - steady-state unit operations

- Implemented in commercial software
  - sockets
    - ASPEN+ : Unit Operations & Physical Properties
    - HYSYS : Unit Operations & Physical Properties
    - gPROMS : Physical Properties
  - plugs
    - PROPERTIES+ : Physical Properties
    - MULTIFLASH : Physical Properties
    - gPROMS : Unit Operations

CAPE-OPEN Laboratories Network (CO-LaN)

- **Non-profit organisation aiming**
  - ***"to promote the use and the development of the CAPE-OPEN standards"***
  - ***"to encourage all actions for facilitating the use of CAPE software tools in industry, administration & academia"***
- **Established January 2001**
  - `http://www.colan.org`
- **Diverse tasks**
  - **finalise remaining software interface specifications**
  - **maintain existing standards**
  - **support organisations adopting CO standards**
  - **monitor CO compliance**

Opportunities

- End-users of process engineering software
- Niche software component providers
- System integrators
- Suppliers of Process Modelling Envinronments

Opportunities: end-users of process engineering software

- A wide variety of PMCs to choose from
  - use “best-of-class” components
  - not confined to whatever PME providers can supply
- Combine variety of tools to carry out complex tasks
  - e.g. use gPROMS to model a complex reactor…
  - …then insert reactor model into HYSYS within existing steady-state plant model
- Ensure consistency across tools
  - e.g. use same physical properties software for
    - steady-state simulation in ASPEN+
    - dynamic optimisation in gPROMS
- BUT… support issues need to be addressed
  - who to call when things do not work ?

Opportunities: niche software component providers

- Develop CAPE-OPEN compliant PMCs
  - that can work seamlessly within *any* CAPE-OPEN compliant PME
- Maximise market size
  - e.g. the same physical properties PMC can be used by ASPEN+, HYSYS or gPROMS users
- Particular opportunities for developing countries with strong/emerging software industry
  - PMCs have relatively narrow function
    - usually simpler than PMEs
    - pricing more easily related to end-user benefit & competition
  - minimise required infrastructure
    - distribute over the WWW

Opportunities: system integrators

- **Build new software by combining existing components**
  - **e.g. advanced plant automation environments**
- **Minimise amount of "bespoke" code that has to be developed**
- **Minimise time & effort required to bring new products to market**

Opportunities: suppliers of Process Modelling Environments

- Similar benefits to system integrators

- A changing & confusing world
  - maintaining control of the central environments

    BUT…
  - losing monopoly of components used in these environments

- Several implications not yet fully worked out
  - competition ?
  - pricing ?
  - support ?

A final remark

- **The road towards open architectures in process engineering software is irreversible**
  - **...and CAPE-OPEN has already taken us more than ever before down this road**