

***Product Family Modelling
in The Construction Industry***



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Product Family Modelling

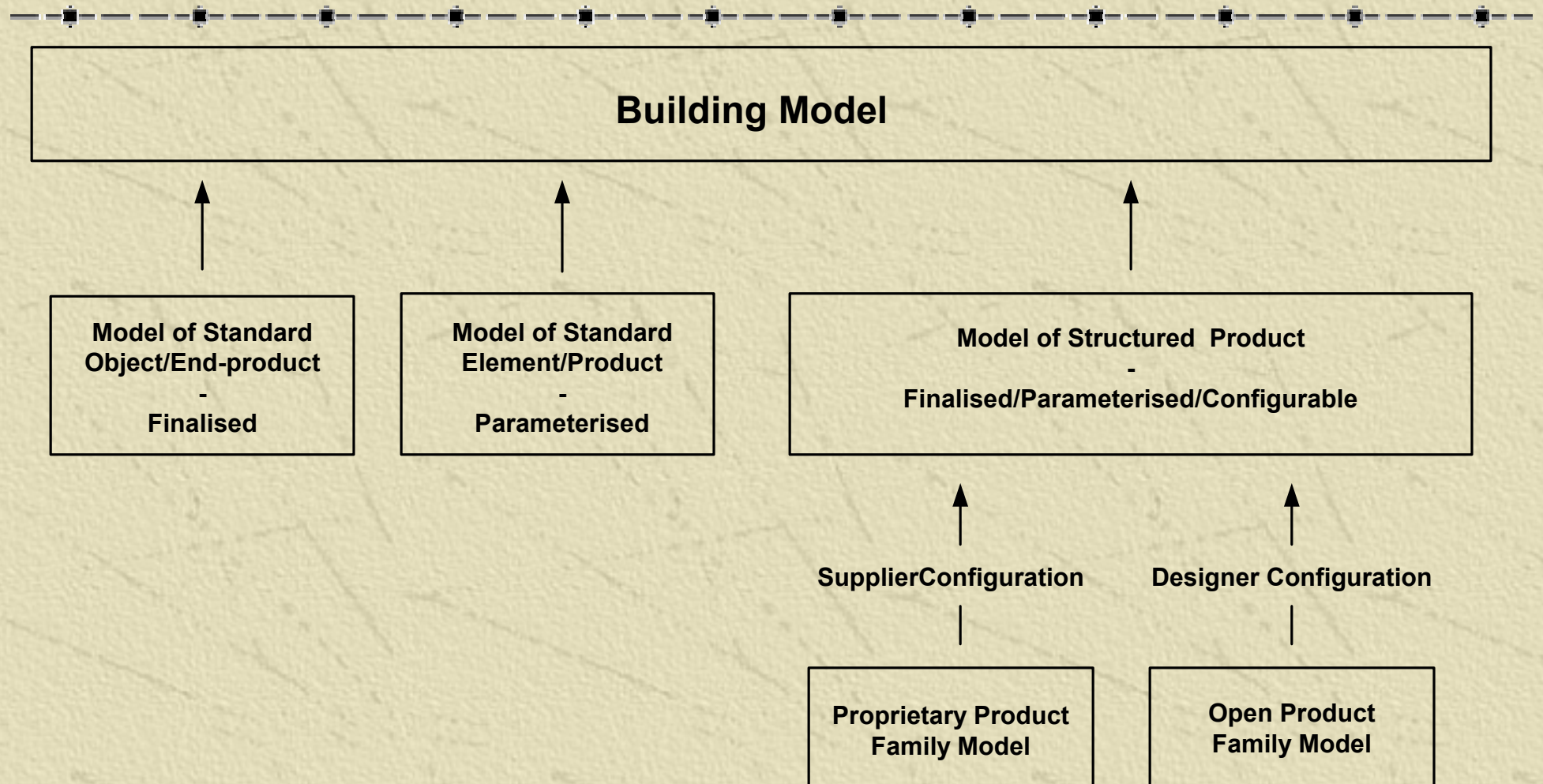
✠ Content

- ◆ **Introduction**
- ◆ **Import of product models into building models**
 - **Different kind of product models**
 - **Object models, GDL, IFC, PLIB, etc.**
 - **Finalised – parameterised – configurable product models**
 - **Product models – towards mass customisation**
- ◆ **Product Family Models as the foundation for building models**
 - **Attributes, domains, domain constraints – relational constraints**
 - **From product family model to finalised product model**
 - **Product configuration: the manufacturer and the building designer**
- ◆ **Sample development projects in Denmark**
- ◆ **Conclusion**

Product Modelling - A Strategic Research Area

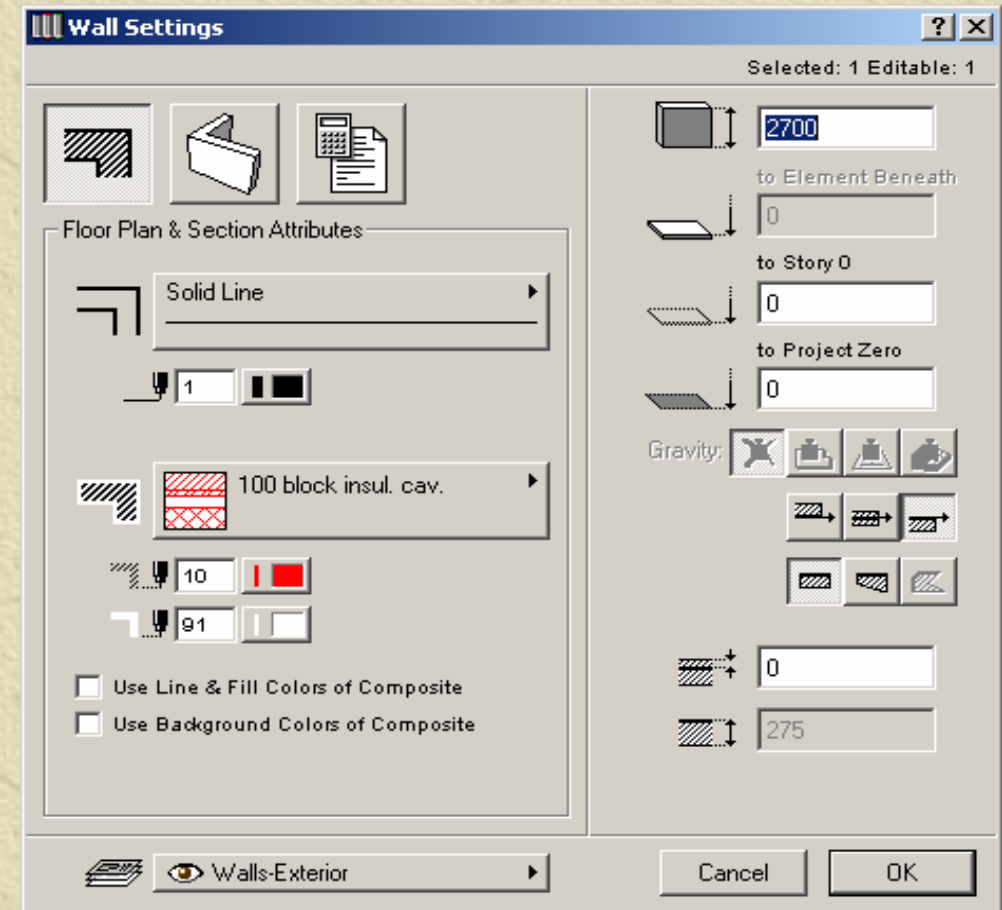
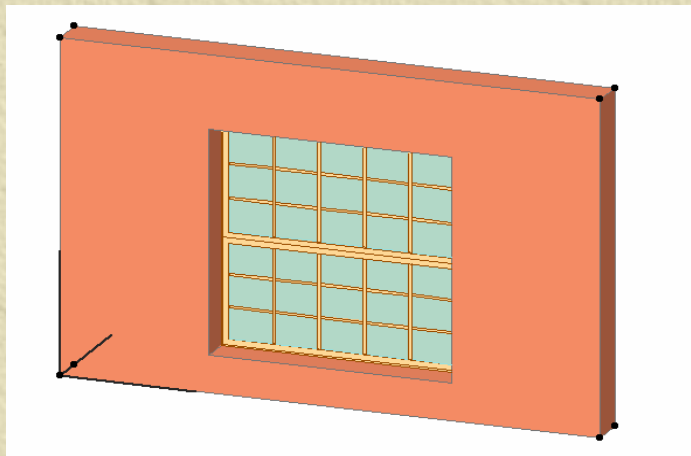
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- ✦ **Design methodologies - the design process**
 - ✦ **Design knowledge – reuse of existing solutions**
 - ✦ **The product model – properties, components and structures**
 - ✦ **Representations - multiple abstraction levels:**
 - ◆ **purpose – use – function – form – structure – performance**
 - ◆ **dual view: requirement versus fulfilment**
 - ✦ **Applications based on product models**
 - ◆ **Graphic presentations – multiple views**
 - ◆ **Model manipulation – virtual Reality**
 - ◆ **Product configurators**
 - ◆ **Product documentation**

Topic: Product Models and The Building Model



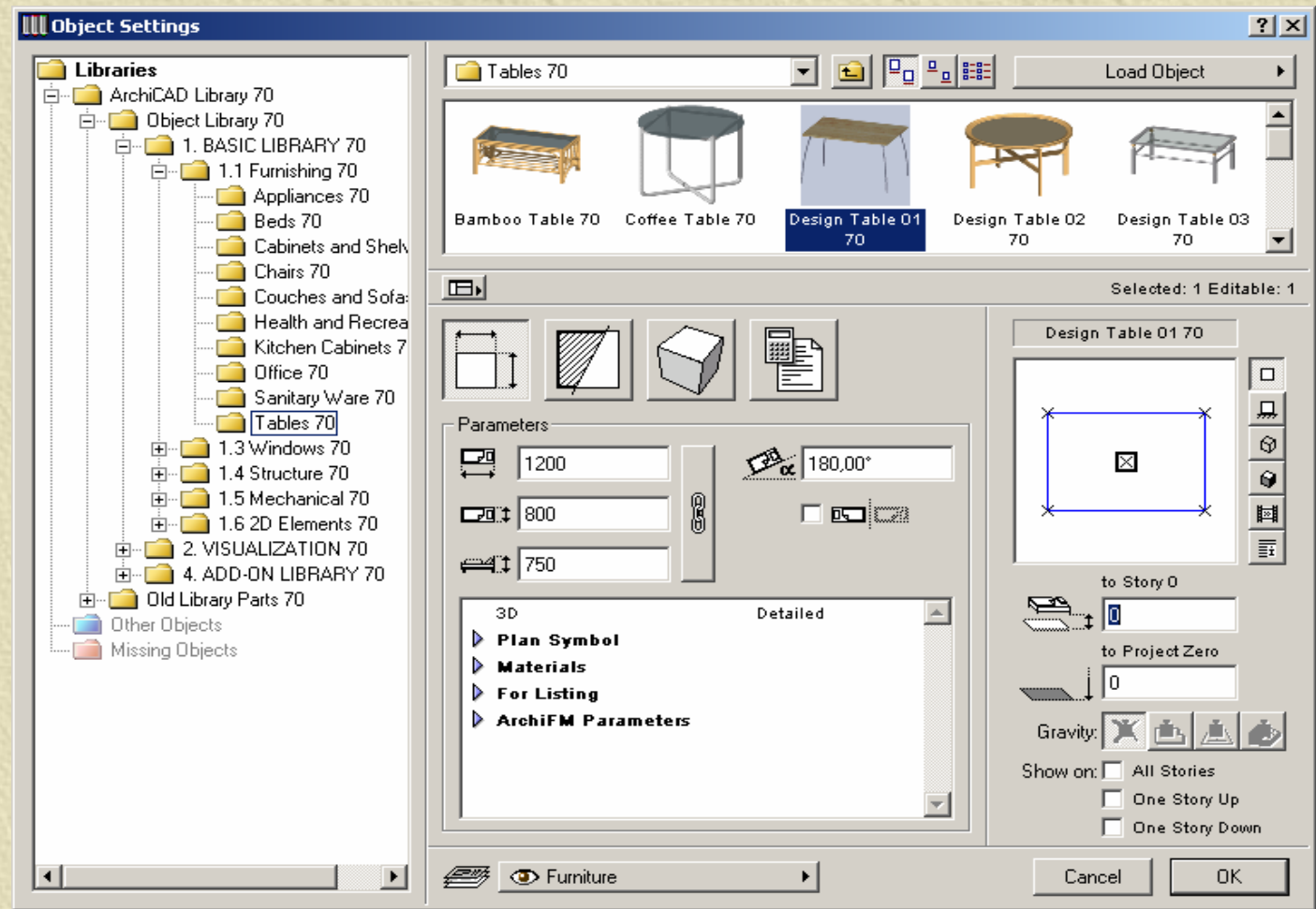
Object Models as the foundation

- ✦ Models are built from objects
- ✦ Object properties are specified
 - ◆ Geometry
 - ◆ Materials
 - ◆ Prices



Building Model Design Tools – Libraries of Object Types

Ex: furniture



Import of Product Models into Building Models

✳ Libraries of object types

- ◆ **Standard object types are included in design systems**
- ◆ **Additional library object types can be inserted**
- ◆ **Preliminary design can be carried out by selection of such objects**
- ◆ **Relationships between objects are automatically maintained by the tools**

✳ Insertion of external models of building objects and products

- ◆ **GDL based models – GDL interface is required**
 - **GDL models are parameterised**
- ◆ **IFC based product models – interface is required**
 - **IFC models are not parameterised**
- ◆ **Product models based on the ISO-PLIB standard??**

Exchange of GDL Product Models



- ✦ **GDL objects can be formulated with parameters**
- ✦ **Product families can be represented by GDL models**
- ✦ **Each product family can be represented in one model**
- ✦ **Each end-product is defined by a set of parameter values**
- ✦ **GDL models can be imported into CAD systems e.g. ArchiCAD**
- ✦ **Object-represented models can be build from GDL models**
- ✦ **GDL models can be integrated with larger product models**
- ✦ **A possible basis for product development in networks**

Industrial Foundation Classes (IFC)

✱ **A basis for building modelling**

✱ **IFC is the currently most dominating data model**

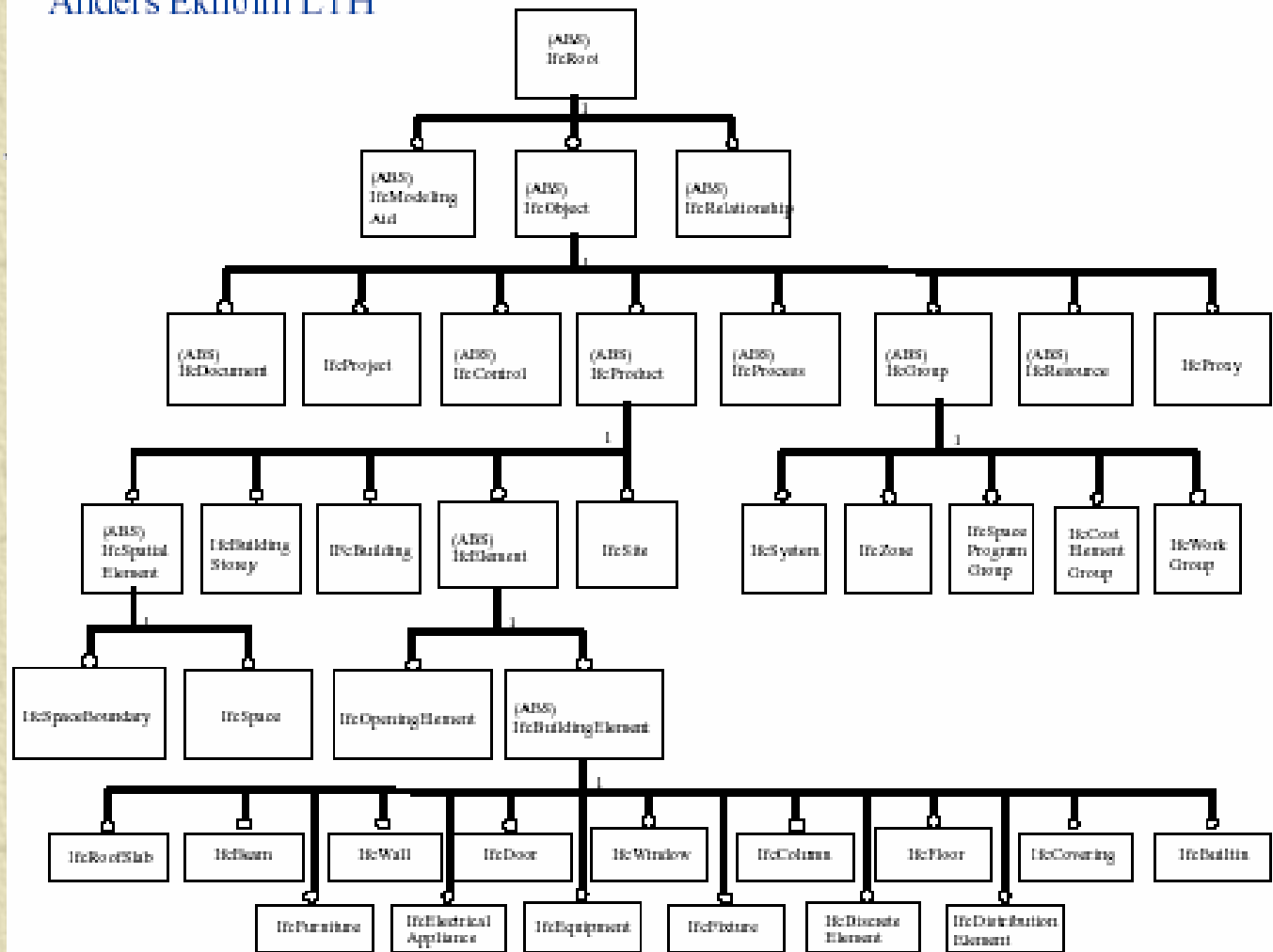
- ◆ **Based on STEP/ISO10303**
- ◆ **Newest version IFC2x(2)**
- ◆ **Approved as ISO/PAS 16739**
- ◆ **Well accepted by leading parties in the industry**

✱ **IFC defines a foundation for building design**

- ◆ **A hierarchy of object types (classification)**
- ◆ **Relationship types for linking objects**
- ◆ **A large set of building object types are defined**
- ◆ **A large set of concepts are defined internationally**

IFC

Anders Ekholm LTH



Objektklasshierarki i IFC 1.5.1 (Projektrapport Tarandi 990305)
 IFC saknar åtskillnad mellan funktionella och fysiska objekt

Building Modelling With IFC Objects

✳ IFC Object Types

- ◆ **Contain an initial set of attributes**
- ◆ **Additional attributes can be defined – property sets**
- ◆ **Attributes defining 3D geometry**
- ◆ **Additional attributes for materials, surfaces, cost, etc.**

✳ IFC based objects in the building model

- ◆ **Building models are created by selection of object types**
- ◆ **Specified by assigning attribute values**
- ◆ **Stepwise specification can be performed to further detail**
- ◆ **Objects can be exchanged via a standard format**
- ◆ **Export from and import into a number of building design systems**

✳ IFC is a foundation for developing product models

Product Models – Towards Mass Customisation

✳ Three forms of product models

◆ Finalised models

- All attribute values are assigned unchangeable values
- E.g. special building objects, as-built end-products, etc.

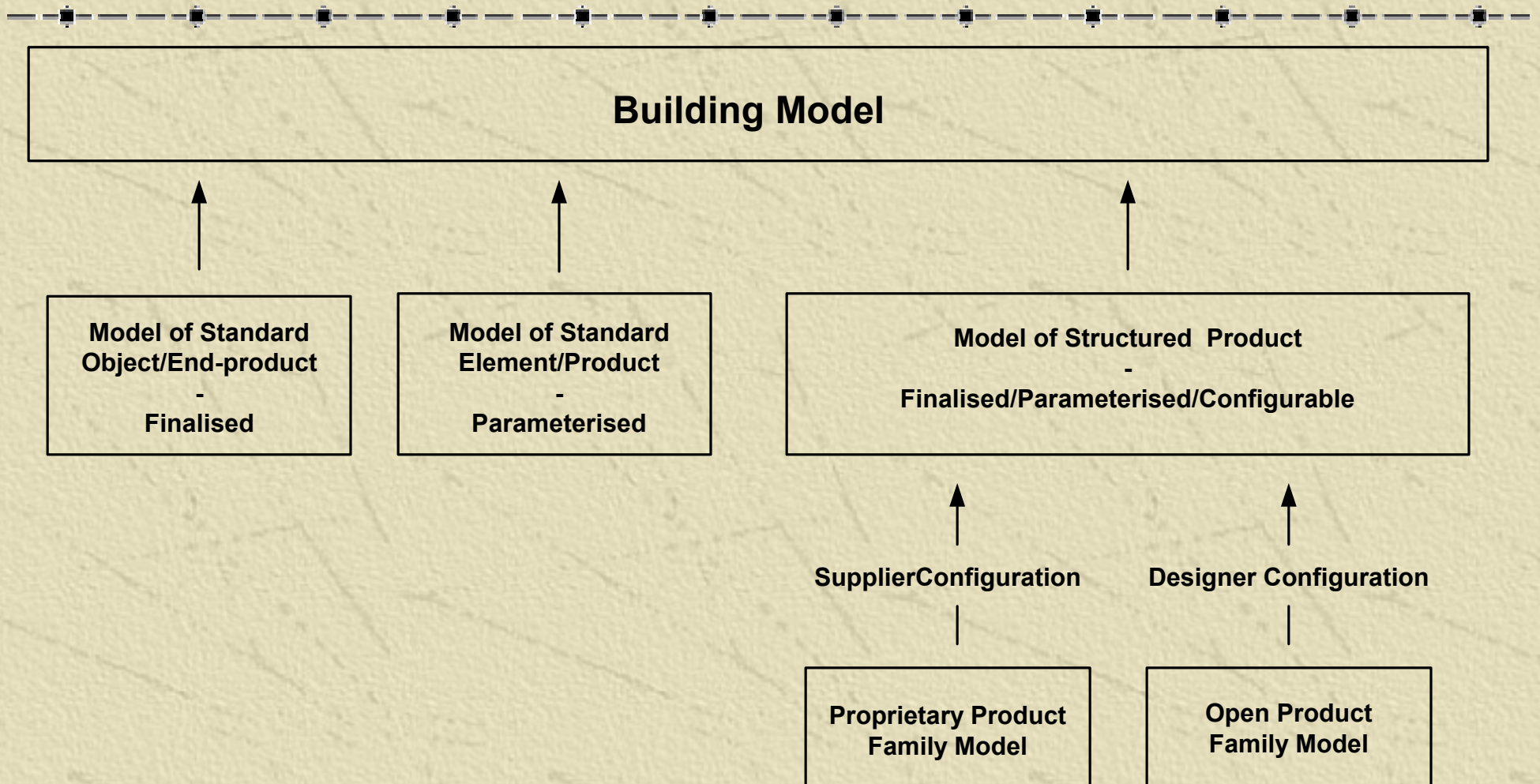
◆ Parameterised models

- Values of a subset of the attributes can be modified
- E.g. most building elements, windows, doors, beams, columns, etc.
- Building products like stairs, gates, etc. could be developed
- Often transformed to finalised end-product models

◆ Configurable models – models of product families

- Attributes as well as components and structure are defined
- Can be reduced to parameterised or finalised models

Product Models and The Building Model



Product Family Models is The Foundation

✱ Product family models are often proprietary

- ◆ Suppliers perform the configuration to finalised product models

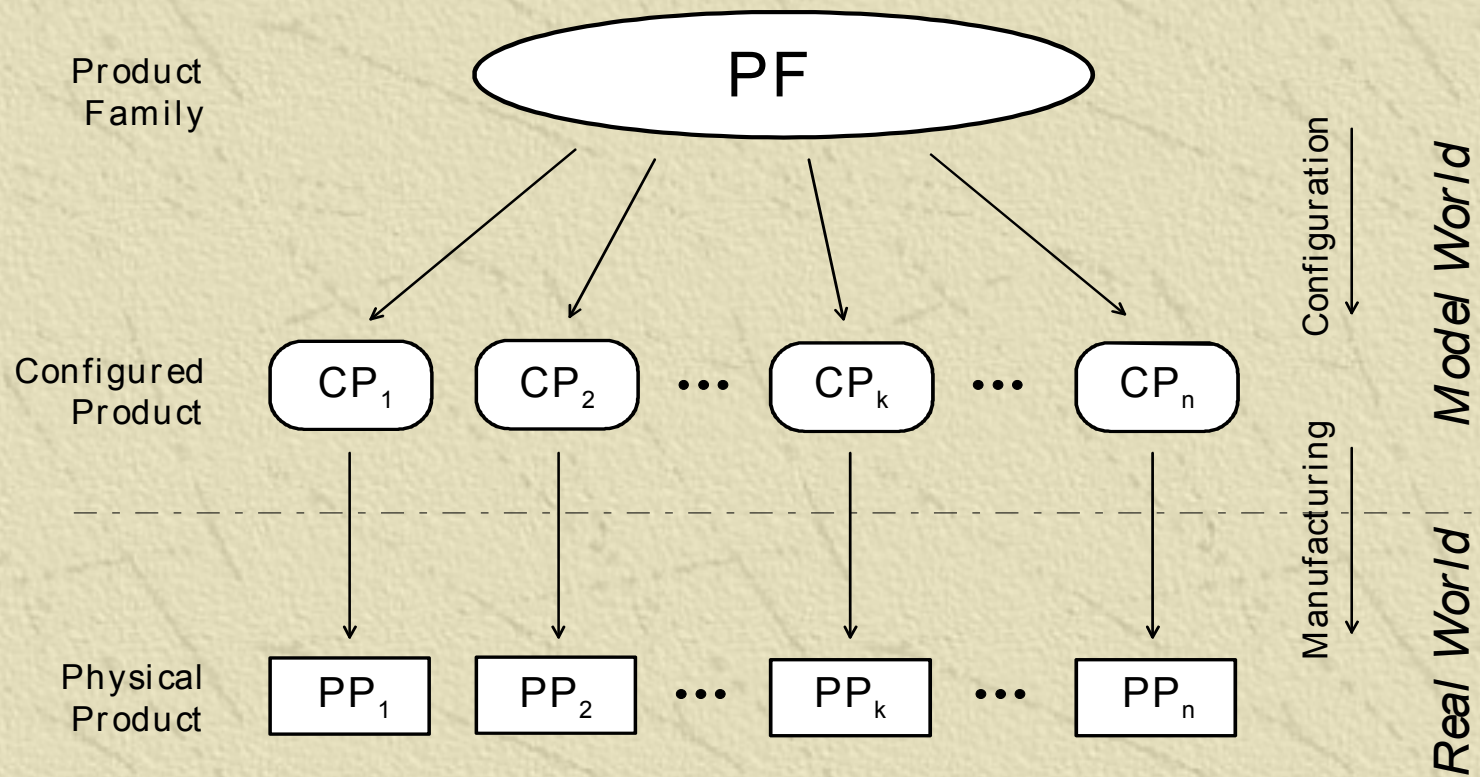
✱ Building architects need parameterised or configurable models

- ◆ Some degree of openness is required
- ◆ With open product family models, the designer can perform configuration

✱ New approach: semi open product family models?

- ◆ The manufacturer can perform configuration to a certain point
- ◆ The manufacturer delivers a still configurable or parameterised model
- ◆ The designer can perform further configuration or finalisation
- ◆ Each manufacturer can secure his competitive uniqueness
- ◆ The designers can maintain a higher degree of freedom

Product Models and Product Family Models



Modelling of Products and Product Families

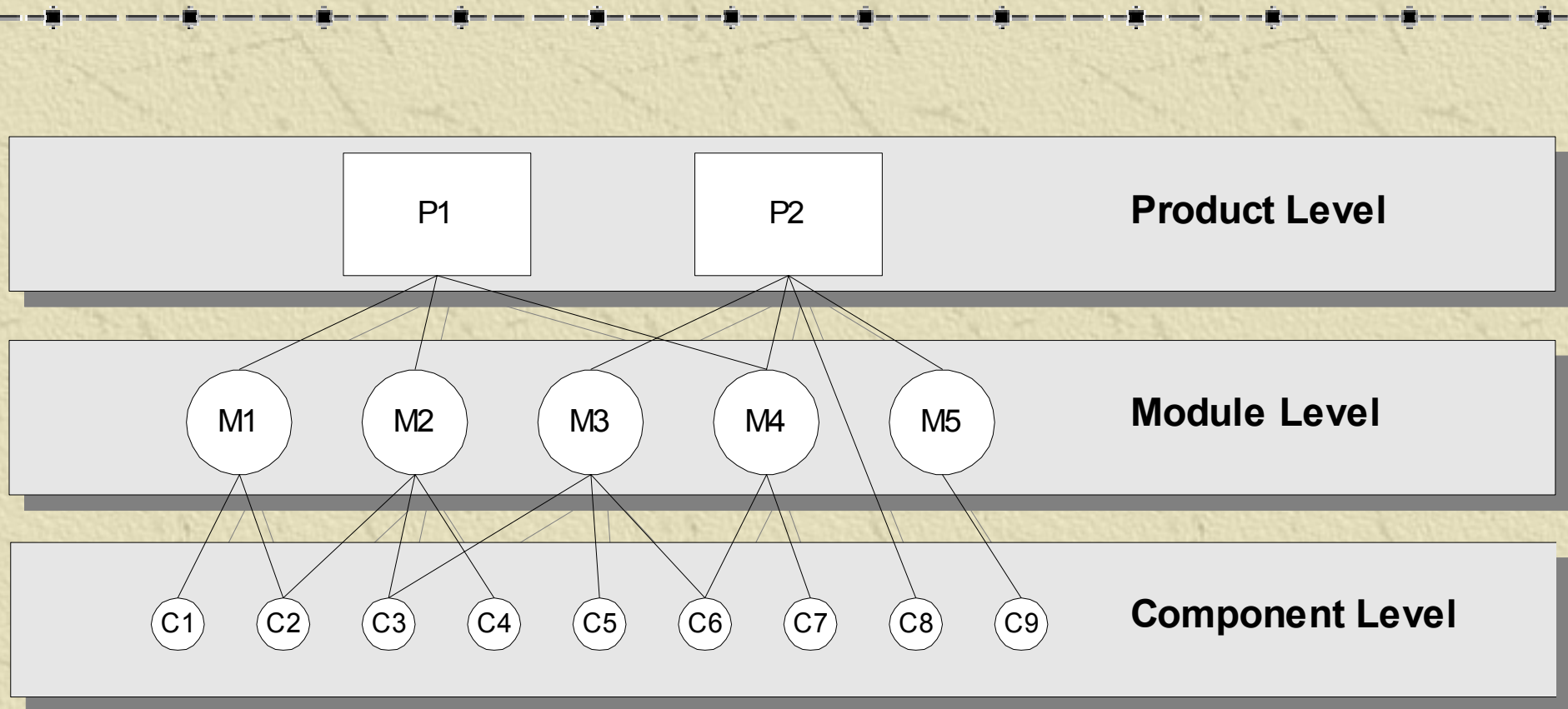
✦ **Basic concepts**

- ◆ **Product Model – the synthetic view**
- ◆ **More precise concepts: Product Family and Product Family Model**
 - **Product family: set of end-products**
 - **Product family model: synthetic and generic model of product family**
 - **Product model: model generated from a product family model**
 - **Product: end-product manufactured from its product model**

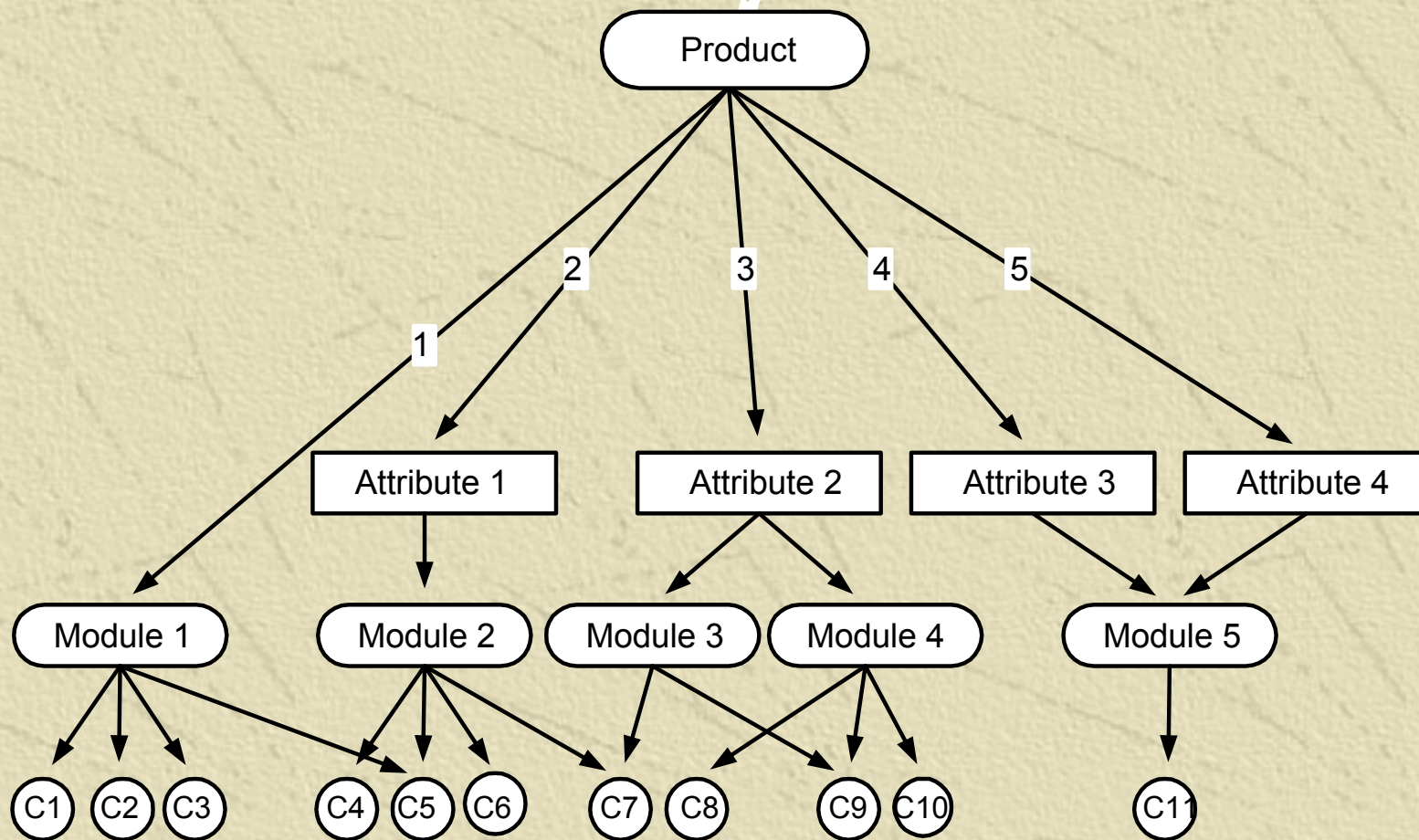
✦ **Product family model**

- ◆ **Key issues: determination of properties of the end products**
- ◆ **Structural view of product families**
 - **Modularisation, modules versus attributes, functionalities**

Typical view: the structural view



Product Specification: attributes versus modules



Product Family Models

✦ Attributes - product attributes and module attributes

- ◆ Data types: numeric, boolean, string, etc.
- ◆ Domains: the set of possible attribute values
 - enumerated values
 - intervals
- ◆ Domain constraints: OneOf, AtMostOne, AtLeastOne, AnyOf, Optional
- ◆ Default values, optional

✦ Examples related to doors:

Door.Material OneOf [Wood,Plastic,Metal] Default[Wood]

Door.Doorstep Optional [Yes,No] Default[Yes]

Door.Handle AtMostOne [<list of handles>]

Lock.Screws one of [0..10]

Product Family Models

✱ Relational Constraints

- ◆ Define the solution space
- ◆ Set of relationships – relation expressions
 - logical, examples:
 - Door => Lock
 - Door.Material[Wood] => Lock.Screws[8]
 - Door.Material <=> Doorstep.Material
 - arithmetic, example:
 - Door.Hinges >= [2]
- ◆ Inference engine is very efficient:
 - the inference time decreases with increased number of user selections

✱ Baan: E-Configuration Enterprise system – The Cava Language

From Product Family Model to Finalised Product Model

✦ The product family model can be developed from top

- ◆ Level of detail is related to the need for configuration
- ◆ Further details can be added simultaneously

✦ A configurator can be developed based on this model

- ◆ Normally configurators produce models of finalised end-products
- ◆ The product model may be public but the configurator is proprietary

✦ It should be possible to generate public models

- ◆ Such models could be parameterised or configurable on a lower level
- ◆ With constraint based configurators it is easy to generate such models
- ◆ The already made configuration decisions can simply be added to the original constraints as additional constraints
- ◆ A derived configurator can be generated

Sample development projects in Denmark

✳ **F. L. Smidt & Co.**

- ◆ **Product: cement manufacturing plants**
- ◆ **Configurator for tender support**

✳ **Aalborg Industries – www.aalborg-industries.com**

- ◆ **Product: modular boilers**
- ◆ **Configurator for calculation of budget cost**

✳ **Demex Electric – www.demex-electric.dk**

- ◆ **Product: electric control panels**
- ◆ **Product configurator for layout and component selection**

✳ **Triax**

- ◆ **Product: Parabolic antennas**

AFBRYD | GEM OG FORTSÆT TIL TILBUDSLISTE

Ydre forhold | Afg. >=63A | Afg. < 63A ✓ | Styring ✓ | Disp. felter

Ydre forhold

Netselskaber: ✓ Energigruppe Jylland

Tavleforsyning: ✓ Fra anden tavle

Normer: ✓ EN60439-1/EN60439-3 (I

Systemjording: ✓ TT

Kortslutningsstrøm: ✓ 10 kA

Leder i tilgang: ✓ AI

Lederspec tilgang: ✓ 1 x 4 x 25

AI klemmer tilgang: ✓ Ja

Fordelingstavle

Mækestrøm: ✓ 125 A

Afregningsmåling: ✗ Nej

Placering: ✓ Gulv

Kapslingsklasse: ✓ IP20xc

Beskyt. mod ind. berøring: ✓ I tavlen

Formkrav: ✓ Form 1

Låger i afgang <= 63 A: ✓ Uden rude

Kapsling: ✓ Cubic

Komponentfabrikat: ✓ ABB

Disponibel plads [%]: ✓ 20

Forsyningsadskiller

Type: ✓ Lastbryder 125 A

Umålt strøm (Max 63 A)

Afgange: ✓ Ingen

Instrumentering

Ampm./voltm.: ✓ Ingen

Transientbeskyttelse

Transientbeskyttelse: ✗ Nej

Fasekompensering

Type: ✓ Ingen

Sektioner

Antal: ?

Sektionering: ✓ Ingen

Levering

Postnr: ✓ 7400

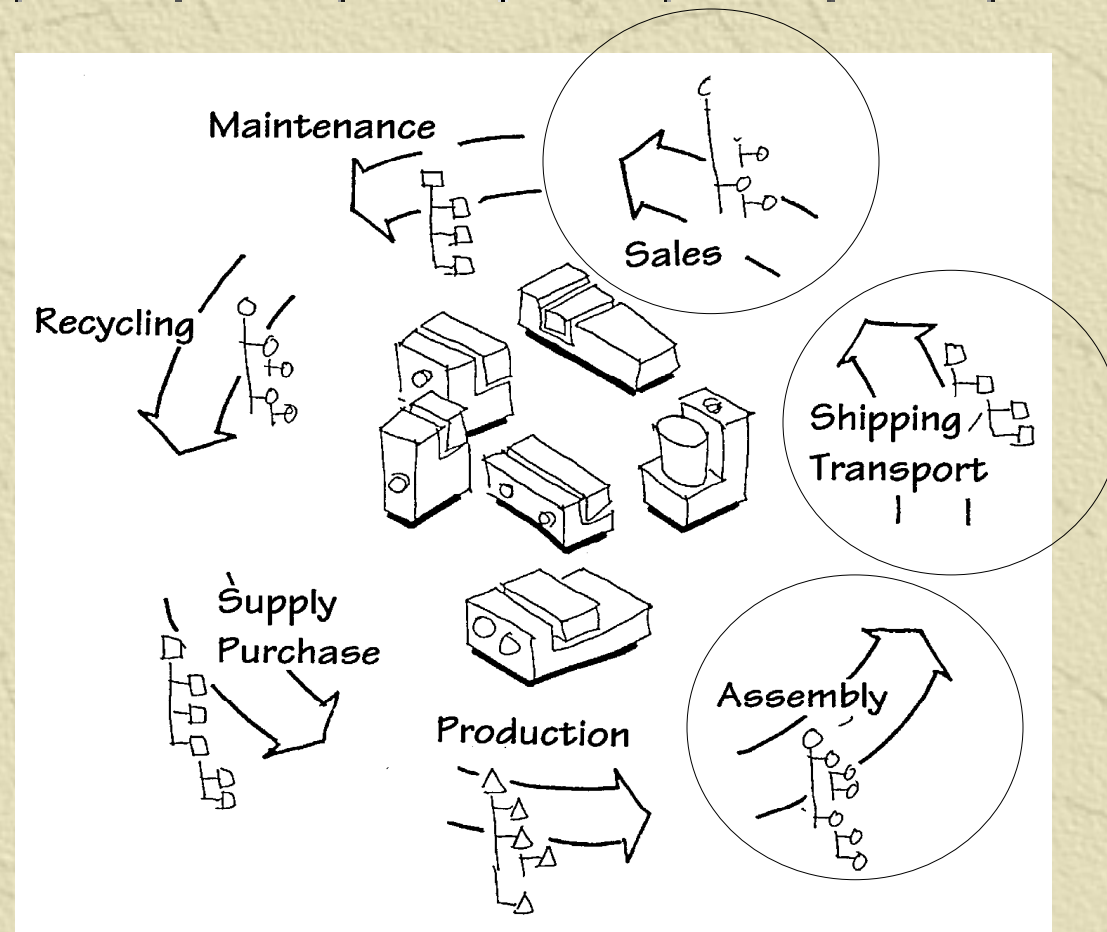
Tavlepris:	799
Tillæg for AI. klemmer:	0 dkr
Tillæg for fasekompensering:	0 dkr
Tillæg for fragt:	0 dkr
Totalpris:	799

Tavlehøjde (M):	0
Tavlebredde (M):	0
Tavledybde (M):	0

Fyldningsgrad sidste søjle: **0**

American Power Conversion (APC) www.apcc.com

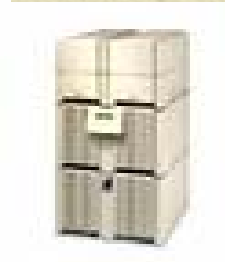
- ✦ “End-to-end Availability Solutions for Data Networks”
- ✦ APC provides power protection, environmental control and site monitoring services that are designed to proactively identify and correct problems before downtime occurs.



APC: Product Selector/Configurator

Solutions

Simple UPS accessories Configurator



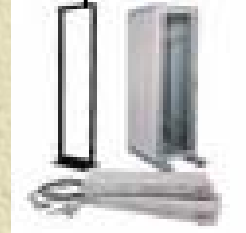
Cable Selector



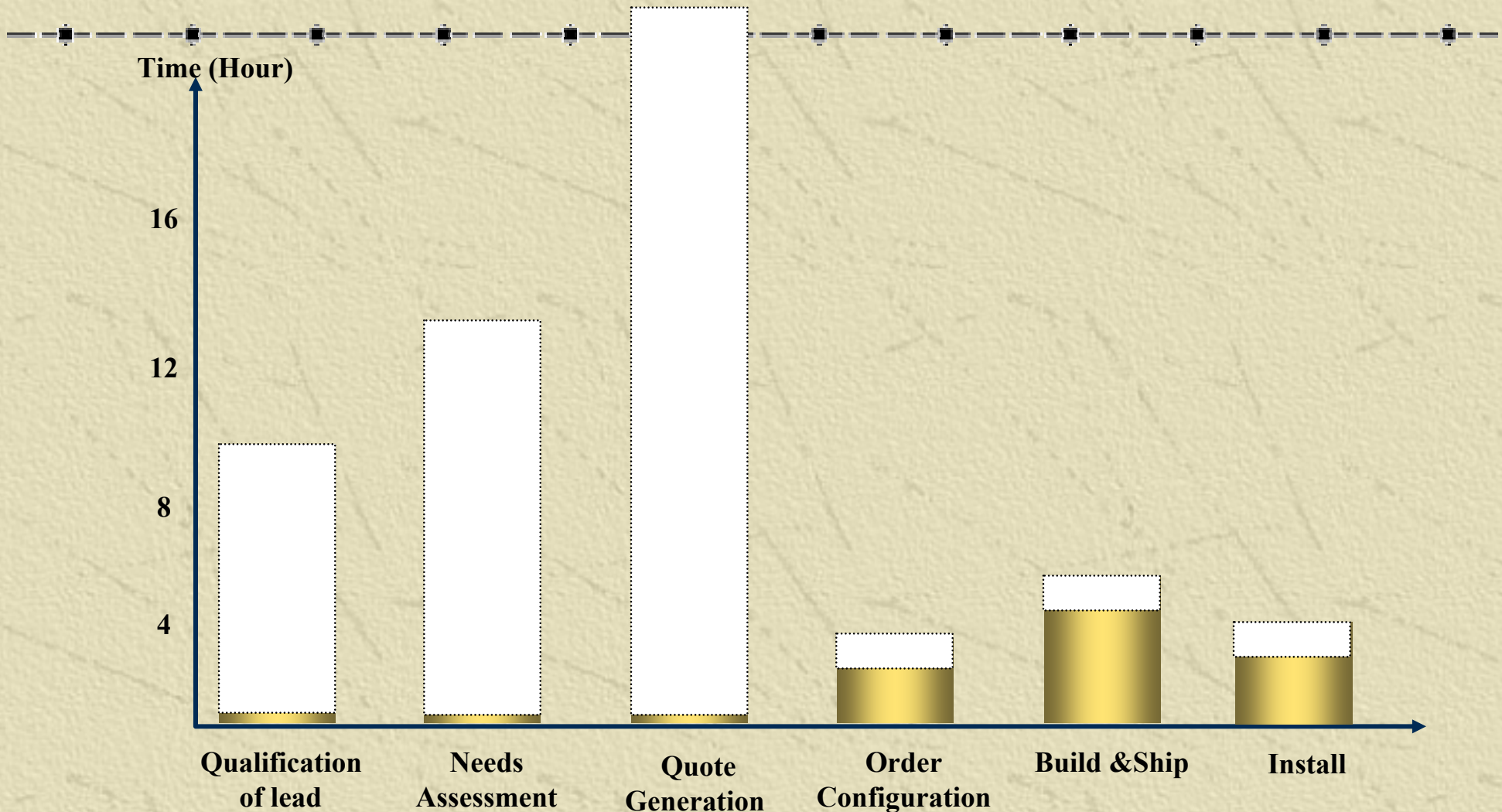
Service Selector



Complex Solution Configurator



APC: Results / Outcome



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Conclusion



- ✦ **Product Modelling - A Strategic Research Area**
- ✦ **Building Modelling: Industrial Foundation Classes (IFC)**
- ✦ **Product Models – Towards Mass Customisation**
 - ◆ Finalised – parameterised – configurable
 - ◆ A need for import of open configurable models into building models
- ✦ **Product Family Models – The Basis For Product Configuration**
 - ◆ Object-oriented representation of product families
 - ◆ Definition of attributes: data type, domain and domain constraints
 - ◆ Definition of relational constraints
- ✦ **Balance between proprietary and public information**
 - ◆ Makes it possible to provide semi-open configurable models