Reference Architecture for Computer Integration in Denmark

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Abstract

This paper gives an overview over the principles and the existing integration framework for a new set of projects in Denmark, intended to develop a common reference architecture for the integration of design, construction, distribution and use of building products. The budget for these projects is 6 million dkr.

The new projects are based upon existing reference architectures from previous projects - called "DIGIDOK" (Digital building documents) and "EITI" (Contractors Association IT-initiative) - which over the past 4 years have provided a set of generic application models, data models and EDIFACT-specifications. The total budget was here around 15 million dkr.

The new projects serve as a coordinating link and part of a greater IT-inititiative "datainterchange in the construction sector" comprising 15-20 subprojects with a budget of around 30 mio dkr.

1. SYSTEMS SPECIFICATIONS ARCHITECTURE

The purpose of the IT-inititiative "datainterchange in the construction sector" is to create a common basis for the integration of information systems in the sector. The results will be a general set of "systems specifications" - i.e. a set of general submodels decribing future data processing & communication systems in the construction sector - serving as a common basis for systems development cooperation between users and software houses in the sector.

The IT-initiative publications are therefore formed in such a way, that the single chapters are referring to - and can be integrated as parts in - a common framework of results. This result and systems specification structure is illustrated below.

SYSTEMS SPECIFICATIONS ARCHITECTURE:

MANAGEMENT LEVEL	FUNCTIONAL MODEL	COMMUNICATION MODEL	DATA MODEL
STRATEGIC	Functions	Interfaces	Know how
TACTICAL	Activities	Documents	Concepts
OPERATIONAL	Routines	Data elements	Attributes

In one direction the documentation is divided in 3 submodels: a

functional model, a data model and a communication model. In the other direction the documentation is divided according to the management levels in the enterprises using them: as a basis for strategic, tactical and operational planning and systems development.

The purpose of this document structure is:

- to ensure a practical and logical coherence in the IT-initiative result documentation

- to facilitate a development of the results as a combination of a praxisoriented "bottom-up" work in different applications and trade areas - and a more theoretical, generalizing "top-down" work

- to make it easier to ensure a current coordination of the concepts and publications in the different projects.

2. RELATIONSHIPS BETWEEN FUNCTIONAL, DATA & COMMUNICATION MODELS

As we have considered this system specification architecture very carefully, I shall summarize our arguments here.

Each system specification submodel shall describe separate sides of the total information system for a construction project. The relationships between the 3 models are illustrated in figur 1 (encl. 1) and are the following:

- the functional model is a **data processing model** (process)
- the data model is a **data store model** (database)
- the communication model is an **interface model** (document)

The basic relationships are, that the documents on one side are input and output to and from the processes - and that their data content on the other side has to be represented in the data model. All datanames in the documents represent concepts, which are defined in a common data catalogue (data dictionary).

	SYSTEMS SPECIFICATIONS CONTENT & USE:		
TARGET GROUP	**FUNCTIONAL MODEL**	**COMMUNICATION MODEL**	**DATA MODEL**
USERS - manual system	ACTIVITIES data- processing	DOCUMENTS data- presentation	CONCEPTS data- interpretation
SYSTEM- DEVELOPPERS - automized system	APPLICATIONS data- transformation	DATA FORMATS data- transportation	DATABASES data- storing

The functional model is the model, we use to **process/transform** our data after - either manually or in automized systems. The communication model is the model, we use to **interchange and present** data after. The data model is the model, we use to **interprete and store** data after.

Therefore the communication model is a model of physical data flows through an spatial interface between two information systems. It is in a broad sense a document model (a message model) - either in the form, documents are transported (f.eks. in EDIFACT-, text- ore CAD-format) or in the form, they are presented to the user (on paper or screen).

3. GENERIC FUNCTIONAL ARCHITECTURES

In one of our new projects: "Functional & data architecture", we want to create a set of general functional models, which represent the future applications in a clear, practical and logical way.

The basic viewpoint is here, that a functional model can be considered as a grouping of processes after one or more "sorting criterias". As you can extract and present data after different views, you can also group and decribe processes dependent of, what the functional model is going to be used for in a given context.

The functional models, we speak of, are going to be used - on different "management and system levels" - to integrate the business management as a hole with the activity and product management in each construction project. We therefore need a set of generic functional models illustrating different aspects of that management process, and which can be integrated as elements in total systems models.

We operate among others with 3 generic functional models, which are further described in the EITI-publications (see ref.1):

- basic processes in the control circle
- construction project phases
- construction project property applications

It is the intention to develop other generic functional models. The models shall specify the construction process to a varying degree of detail - and make it possible to put the models together on different management levels as required.

In the bottom of all the functional models lie the basic processes in the control circle as illustrated in figur 2 (encl. 2). The kernel in the concept of management is "planning, decision, influence and control in order to realize a defined goal or action program".

The management can include the implementation of more or less of a construction project: one or more phases, some selected activities or products - or certain groups of the construction properties. This is illustrated in the following schema, which shows the reference architecture, we have chosen for the construction phases in one direction - and the construction project property applications in the other.

The construction design and management process is characterized as being a successive specification, disposition and realization

of properties linked to the finished construction result and the resources allocated in a cooperation between the participating agents. Handling all these properties the parties often use the same type of applications.

In order to create a common reference framework for the interaction between these applications we here use the "logical application modules" shown in figure 3 (encl. 3), where each module handle a selected group of properties. In the context of each application it is possible for the users to cooperate about the planning, decisionmaking, influencing and controlling of selected properties linked to the project activities and products.

The application modules are structured relating to following property groups - with names relating to these attributes:

PROPERTY APPLICATION MODULES:	**CONSTRUCTION PHASES ==========>> Design Production Distribution Use**
Visual design & management:	geometrical and visual properties
Quality design & management:	performance & material properties
Financial estimating & management:	quantities and prices
Time scheduling & management:	durations and time
Communication & document management:	sales & supply documents
Organization management:	agent responsabilities
Contract management:	rules & contract conditions

The 4 first modules support the basic modelling (planning, decision and control) of the project products and activities. In addition to these are 3 application modules supporting management of the communication and documents and the related management of the project organization and contracts.

4. GENERIC DATA ARCHITECTURES

We similarly intend to structure and systemize the many data processed by these application modules in order to create consensus about a set of generic data architectures describing a common conceptual and logical structure in the business and project data.

In the EITI-project it has been convenient to work with data models at different management and abstraction levels, and we therefore intend to refine these data models in order to get a coherent set of models at 3 levels as illustrated in figure 4 (encl. 4):

- for business management as a hole
- for project management
- for product management: design, production, distribution, use

The high level principles for the information structure - the data architecture - in these data models are desribed by examples from the EITI's data models in the following.

Hypothesis about the recursive product model

Our experiences from the previous IT-projects in Denmark indicate, that it might be possible to create a uniform and strongly simplified data architecture at these levels, if it is based on a purely fundamental, generic data model for product information.

The idea is here, that the high level data models are aggregations of the same basic data model - in principle like a "chinese box system". The aggregated data models would - based on this hypothesis - just be the same data model pointing recursively into itself again and again.

The hypothesis is supported by the fact, that the basic processes in managing a project are the same as in managing the design, production, distribution and use of a product. Consequently the processes would need the same type of information - and the information therefore structured in the same way as the generic product model.

Generic business data architecture

The aggregated data architectures for the business as a hole and for the construction project are ment to give the users and the systems developpers an overview over the relevant "super objects" in the data models, their internal relationships and their correspondence with reality. It is intended to serve as an instrument for integration of applications for business, project and product management.

The EITI-project developed a high level data model for a contractor business, see figure 5 (encl 5), which we use as a starting point for the specification of a similar, general data model for entreprises in the construction sector working with projects. The model structures the conceptual content and the high level relationships in the business as follows:

- business cooperation relationships
- project information: project products and activities
- ressource information: capacity and product information
- financial information

Generic construction project data architecture

Another corresponding high level data model from the EITI-project describes the relationships between the product, activity and organizational structure, see figure 6 (encl 6).

This data model is structured in order to facilitate a successive break down of the project "result structure" in order to group the singles parts of the total design and construction work in a practical "activity structure" - and to delegate the responsabi-

lity in a suitable "organizational structure" by means of consultant, contractor and supplier contracts.

The internal relationships between the project products, activities and project organization are a.o. specified via the conditions (contracts, laws, rules), set by the environment.

Generic data architecture for product information

Referring to these models we have made a scetch of a generic data model for the products in a construction project: building elements, components, work items and resources, see fig 7 (encl. 7).

Based on a few simple principles for subdivision of the product information we operate with following product-submodels, each designed to manage separate aspects of the product creation and use:

- functional product model : PERFORMANCE
- geometrical product model : FORM & LOCATION
- physical product model : PRODUCT-MATERIALS
- time related product model: ACTIVITIES
- structural product model : QUANTITIES

The first 3 are separate static product models, while the 4.th is a time related model for activities, which place the static product models in time. The 5.th specifies the product and performance aggregation by creating the nessessary relations between the 4 other product models.

At each product level (building element, component, work item and resource) we consequently opererate with 4 separate product models, which can be related to the level over or under by means of the "quantity records" - just like "part lists" specify, how much of the "part" the "whole" just above comprises.

This basic product information structure will facilitate the creating of very complex models, which logically are both clear and comprehensive, because one can separate, analyze and aggregate the total digital product model as required. It furthermore give the users a good overview over the content in the product- and project databases.

The product model is in good correspondence with the models and integration principles used in STEP, as described in the article "A proposed integration framework for STEP, William Danner, April 1990. It will now be specified, evaluated and tested in the coming projects in the danish IT-initiative.

5. GENERIC COMMUNICATION ARCHITECTURES

We define the concept "communication model" as: "a common specification of the spatial interface and the correspondant physical data flows between two ore more information systems". The concept has fairly same purpose as STEP's "applications protocol" and is in good correspondence with this. It is a generalization of a group of actual documents.

We define an actual document as "a group of data communicated by one of the project agents at a given time forming an authorized management or contractual basis."

The IT-initiative communication models are to serve as "general interface specifications between different data processing ilands and their environment" making it possible for each business to communicate by relating themselves to one single and common interface specification - i.e. one well defined data flow specification - instead of several individual specifications.

In the coming projects and in the international cooperation there is need for the specification and standardization of two types interfaces:

- **user interfaces** in the form of paper documents or screen pictures, through which the users recieve, interprete and deliver their data

- **EDI interfaces** facilitating an automatic transportation, interpretation and reuse of data.

In both cases the task is to define a common "communication architecture", where the nessessary and sufficient set of generalized documents are defined by their scope, geometrical layout and physical content.

Specifications of interfaces to the users manual systems

In Denmark we currently have following set of user oriented "communication models":

- BPS's common drawing principles
- BPS's common specification principles
- BPS's common building product information system

These models are "interface specifications", which from a user viewpoint structure drawings, texts and product catalogue documents in such a way, that they are practical to produce and easy to interprete. It is a set of common "forms/formats", into which the data suppliers in construction put their data, facilitating a better understanding and interpretation by the data consumer.

These "paper formats" will to a certain extent serve as a basis for the specification of corresponding, electronic screen pictures, which can be applied by the users as common input/output formats on their screens.

Specification of automatic interfaces

The EDI-interfaces - like CAD-drawing formats and EDIFACT formats - are in principle also a set of "common formats", where each data group has a preagreed meaning, documented in a common definition, ensuring a uniform interpretation in an automized system.

The automized interpretation is in praxis provided in that way, that each dataname in the document is supplied with a reference

to an object or attribute name in a common, generic data model. All data definitions are currently gathered and coordinated in the IT-initiative common data catalogue, which successively shall serve as a common data dictionary for the danish construction sector comprising concept definitions for all datanames used.

7. INTEGRATED MANAGEMENT MODEL FOR ACTIVITIES & PRODUCTS

The outlined reference architecture seems in my view to be so universal, that it could be applied in several industries as a general management model for activity and product management. It first turns specific when it is combined with the actual classification systems and applications used in the single branches and trades.

It is characteristic for classification systems, that they - in the context of each industrial business area - are specifications and groupings of the objects shown in the generic data architecture in some practical categories - dependent of the technological state of the industry.

By characterizing the actual things from reality after these categories, each industry can systemize its know-how in an operational way - and consequently achieve the desired "intelligent" and automatic interpretation and reuse of data in the future information systems.

However it will be appropriate to keep the logical data model and the physical determined classification separated, because that is implying, that we can develop and use the same information systems in several branches and in addition work with mutual - local or international - classification systems in the same data processing and communication system.

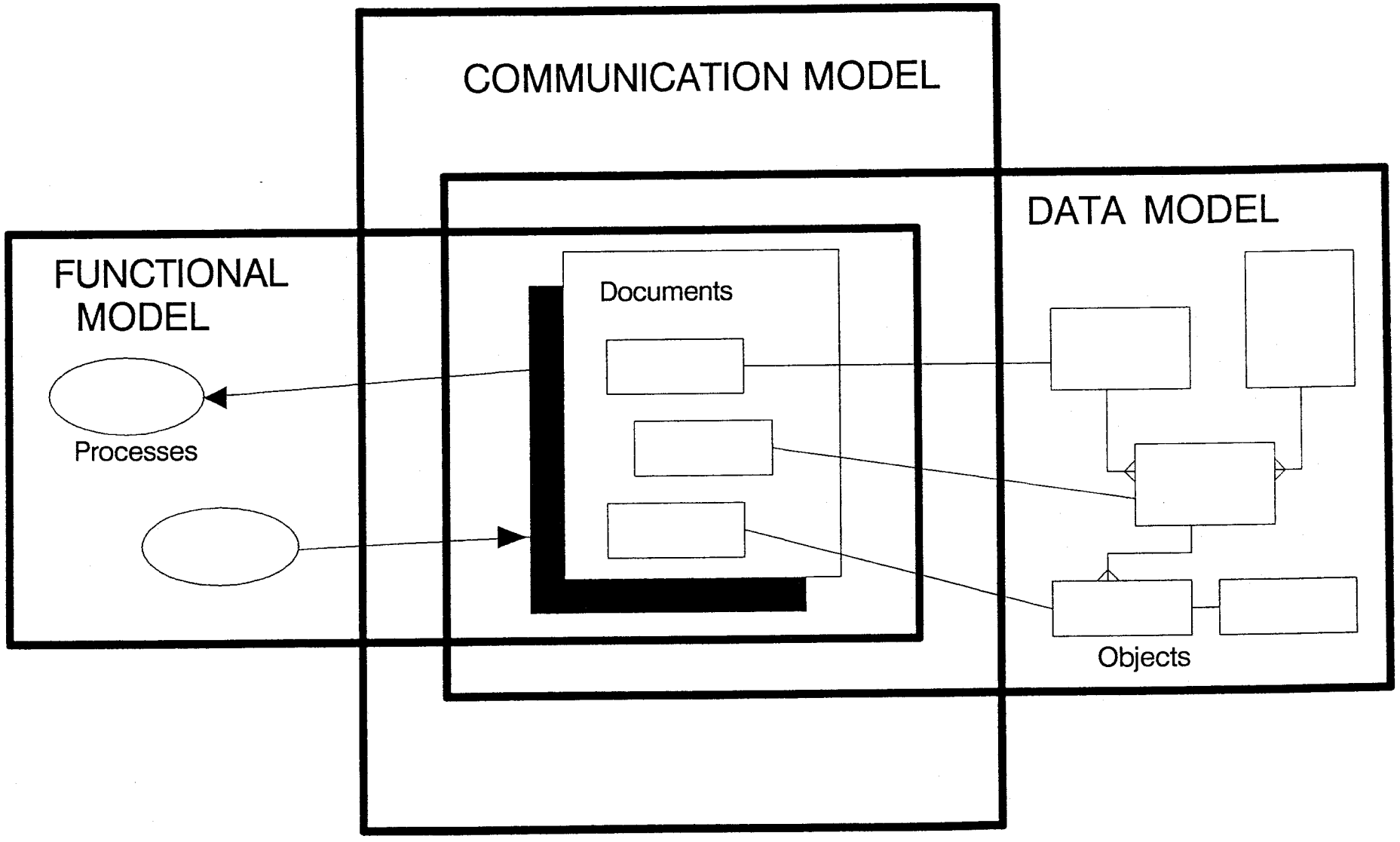
In the projects now starting up in Denmark - with nordic and international cooperation partners - we intend to evaluate and refine these described reference architectures using prototypes, which are developed by the participating entreprises in different application areas.

The projects are carried through in a open cooperation between a great number of consulting architects and engineers, contractors, producers, trading companies and their softwarehouses. The new projects are coordinated with a number of other projects by the BPS-center, and Jesper Vaupel, Building Informatics Ltd functions as a consultant project coordinator for the new projects.

FIGURES (ENCLOSURE):
1. Relationships between functional, data & communication models
2. Basic processes in the control circle
3. Logical application modules for construction management
4. Data model description levels
5. Generic business data architecture
6. Generic construction project data architecture
7. Generic data architecture for product information

REF: EITI-publication: "Datamodels and classification systems"
Danish Contractors Association, Copenhagen, 1990.

RELATIONSHIPS BETWEEN FUNCTIONAL, DATA & COMMUNICATION MODELS.



TRANSFORMATION TRANSACTIONS CAPACITY

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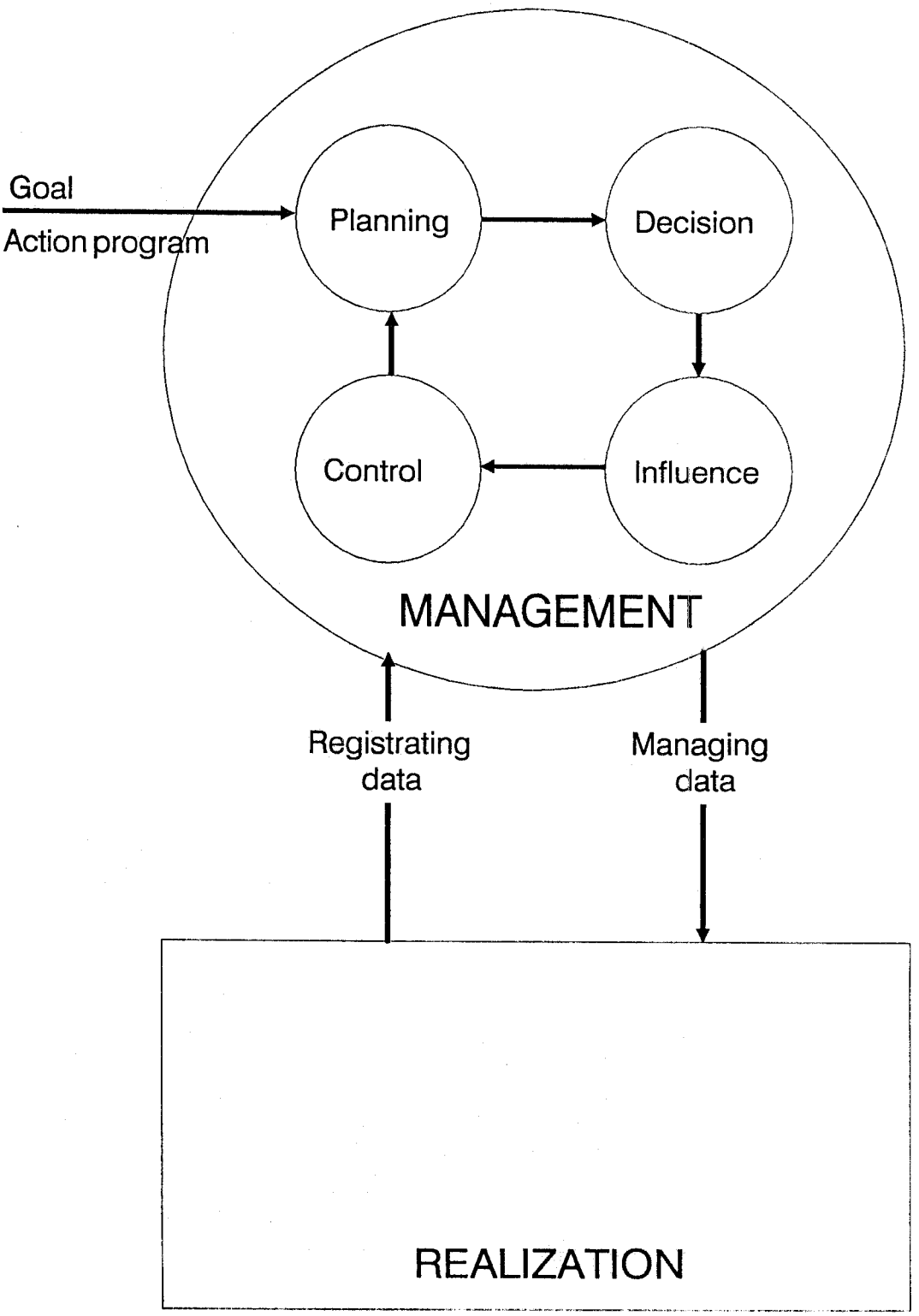
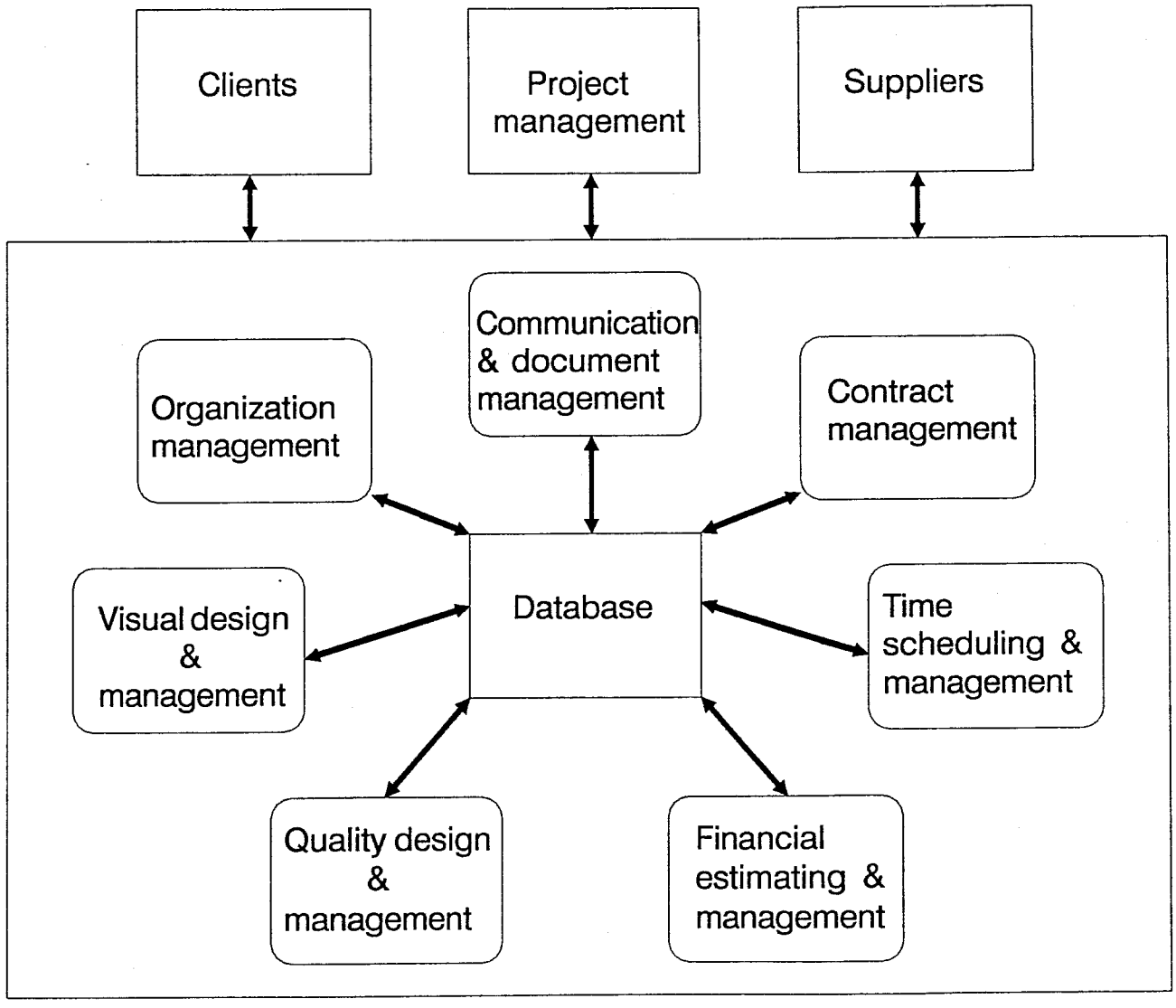
BASIC PROCESSES IN THE CONTROL CIRCLE



LOGICAL APPLICATION MODULES FOR CONSTRUCTION PROJECT MANAGEMENT.



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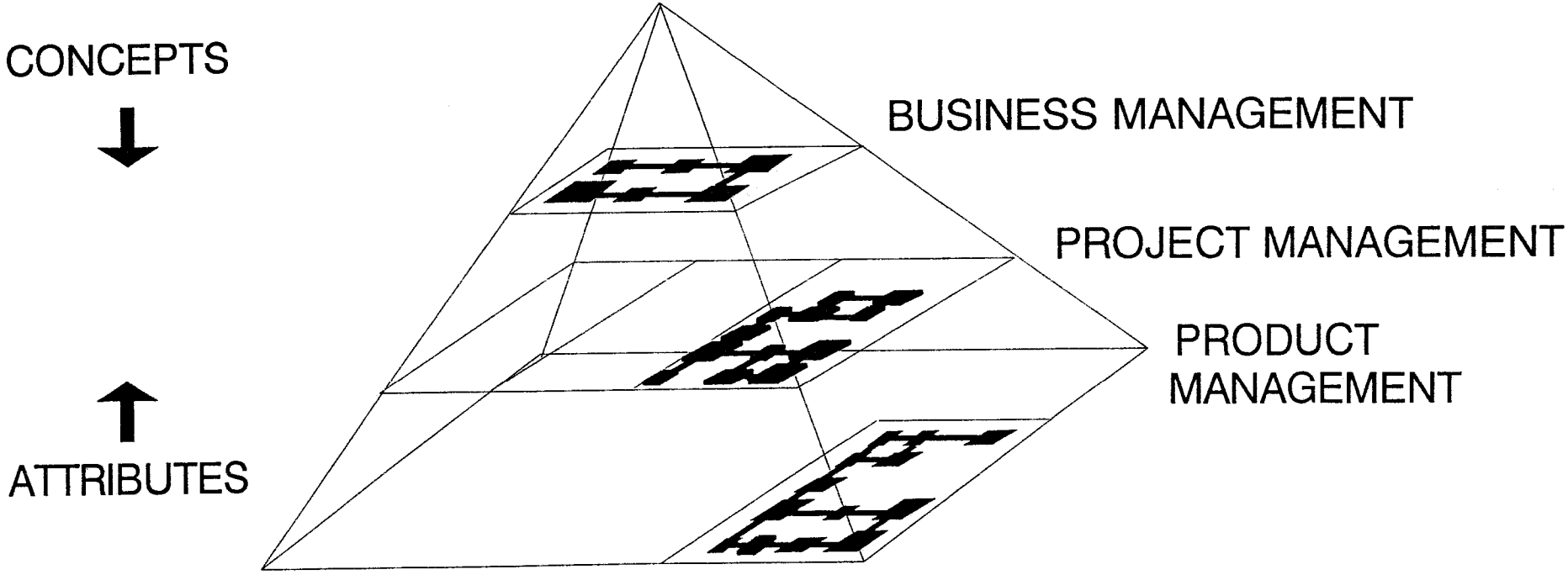
DATA MODEL DESCRIPTION LEVELS.



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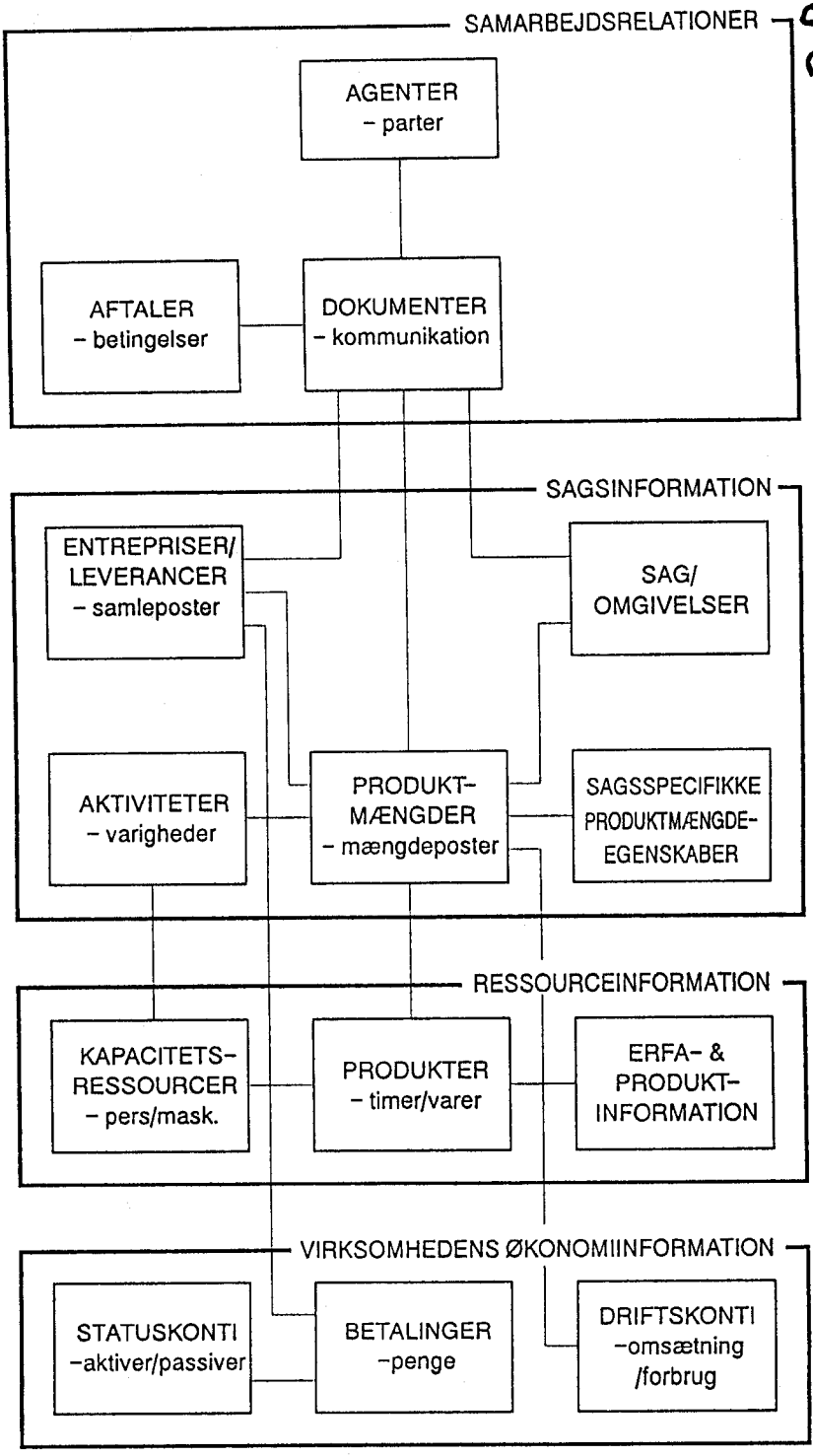
GENERIC BUSINESS DATA ARCHITECTURE

EITI's datamodel for en entreprenørvirksomhed.

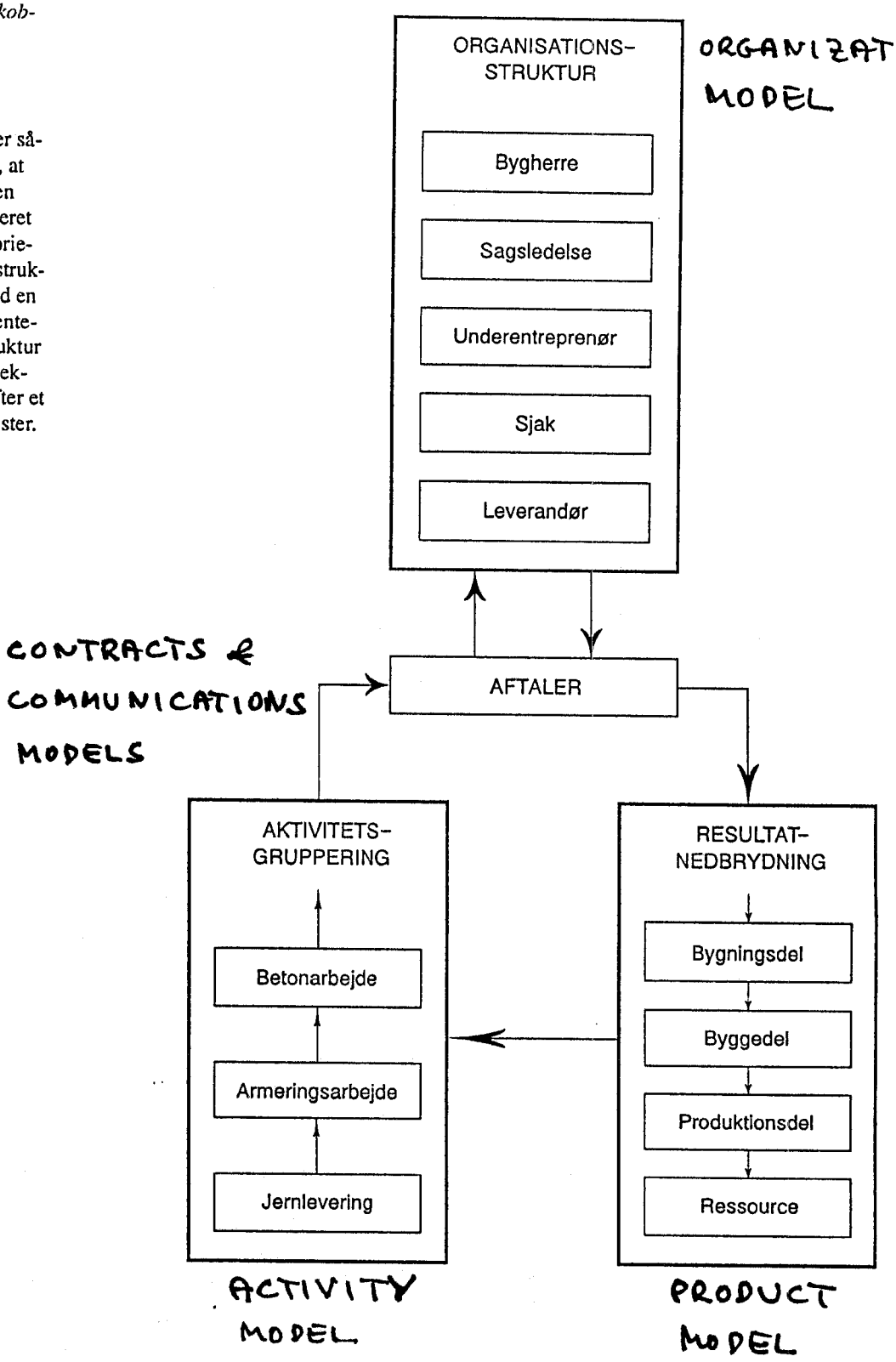
Datamodellen opdeler entreprenørvirksomhedens information svarende til referencerammens styringsområder i virksomhedens sags-, ressource- og økonomistyring samt dens samarbejdsrelationer.



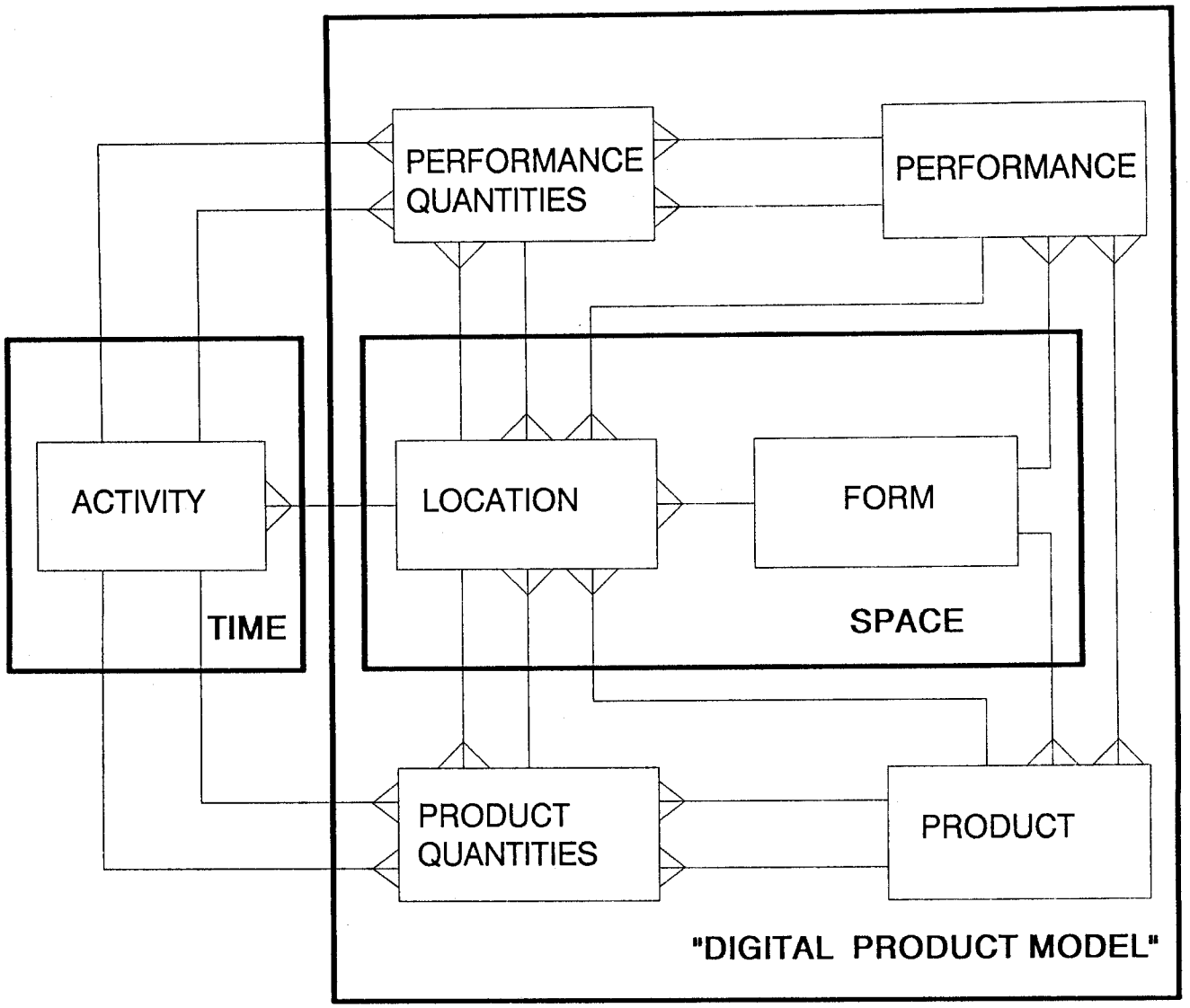
GENERIC PROJECT DATA ARCHITECTURE

Datamodellen kobler resultater, aktiviteter og organisation.

Datamodellen er således opbygget, at den kan koble en funktionsorienteret og en løsningsorieenteret resultatstruktur sammen med en produktionsorienteret aktivitetsstruktur i en ønsket projektorganisation efter et givet aftalemønster.



GENERIC DATA ARCHITECTURE FOR PRODUCT INFORMATION.



TRANSFORMATION
- action

TRANSACTIONS
- communication

CAPACITY
- store