Lecture 3: Entities

3. Entities

- By a domain entity we mean
  - a *fact*[8] which is
    - either an endurant entity, a *part*
    - or is a perdurant entity, that is,
      - an *action*
      - an *event*
      - or a *behaviour*.
  - In contrast to facts we have *concepts*, that is, abstractions derived from facts.
  - Concepts can also be considered entities.
- Domain entities are
  - the things, the tangible, spatial facts we observe and
  - the concepts we abstract from these.

[8] We use the terms 'fact', 'entity', 'particular', 'thing' and 'individual' synonymously

3.0.0.0.1. Examples

Example 6 (Domain Entities) One example per each of four entity categories:

- *part:* transport net;
- *action:* insertion of link;
- *event:* disappearance of a link segment (that is, fraction of a link); and
- *behaviour:* movement of vehicles along net. •

3.1. Parts

- By a part we understand
  - a manifest, an endurant,
    - that is, something we can point to,
    - inert, possibly dynamic, i.e., animate,

    phenomenon
  - or a concept thereof,
  - something that we might (later on) represent as data by a computer.

3.1.0.0.1. Examples

Example 7 (Parts) Five domain examples:

- *Container line:*
  - container,
  - container vessel,
  - container terminal port,
  - bill of lading, etc.
- *Financial service industry:*
  - bank,
  - bankbook,
  - money (notes, coins),
  - insurance policy,
  - stock certificate, etc.
- *Transportation:*
  - net,
  - link,
  - hub,
  - vehicle,
  - driver, etc.

- *Health care:*
  - hospital,
  - ward,
  - bed,
  - patient,
  - medical staff,
  - medical record,
  - medicine,
  - surgery
  - instruments,
  - health insurance policy, etc.
- *Pipeline system:*
  - well,
  - pump,
  - pipe,
  - valve,
  - fork,
  - join,
  - sink,
  - pipeline, etc.

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3.1.1. Atomic Parts

- By an atomic part we shall understand
  - a part
  - which we, as observers, have decided
  - form an indivisible whole,
  - that is, one for which it is not, in a current context, relevant to speak of meaningful subparts.

3.1.1.0.1. Examples

Example 8 (Atomic Parts) Five domain examples:

- *Container Line:* container, bill of lading, way bill.
- *Financial Service Industry:* bankbook, money; insurance policy; stock certificate.
- *Health Care System:* bed, patient, medical record, health insurance policy.
- *Pipeline System:* well, pump, pipe, valve, fork, join, sink.
- *Transportation System:* link, hub, vehicle, driver. •

3.1.2. Composite Parts

- By a composite part we shall understand
  - a part
  - which we, as observers, have decided
  - consists of one or more proper parts
  - also referred to as subparts.

3.1.2.0.1. Examples

Example 9 (Composite Parts and Subparts) Five domain examples:

- *Container Line:* container vessel and its bays; bay and its rows; row and its stacks, stack and its containers.
- *Financial Service Industry:* bank and its accounts.
- *Health Care System:* hospital and its wards; ward and its bedrooms, bedroom and its beds.
- *Pipeline System:* pipeline and its wells, pumps, pipes, valves, forks, joins and sinks.
- *Transportation System:* net and its hubs and links. •

3.1.3. Part Attributes

- By an attribute we shall mean a pair:
  - a type name and
  - a value (of that type).

3.1.3.1. Atomic Part Attributes

- By the attributes of an atomic part we mean
  - the set of properties (type names and values)
  - that we have decided
  - together characterise that atomic part
  - (and all of the atomic parts of the same type).

3.1.3.1.1. Examples

Example 10 (Atomic Part Attributes) Five domain examples:

- *Container line:* `container attributes:` length, width, height, weight, refrigerated or not refrigerated, physical location, contents, etc.
- *Financial service industry:* `account attributes:` interest rate (on loans), yield (on deposits), owner(s), maximum credit, current balance, etc.
- *Health care:* `patient attributes`: name, central personal registration identifier, gender, birth date, birth place, nationality, weight, height, insurance policies, medical record, etc.
- *Pipeline system:* `pipe attributes`: circular diameter, length, location, maximum laminar flow, current flow, guaranteed maximum leak (in volume/second), current leak, etc.
- *Transportation:* `link attributes`: length, location, link state (open in one direction or the other or open in both or closed in both directions), link type (road, rail, sea, air), etc. •

3.1.3.2. Composite Part Attributes

- By the attributes of a composite part we mean
  - the set of properties (type names and values)
  - (exclusive of all subparts of that composite part)
  - that we have decided
  - together characterise that composite part
  - (and all of the composite parts of the same type).

3.1.3.2.1. Examples

Example 11 (Composite Part Attributes) Five domain examples:

- *Container Line Attributes:*
  - name,
  - legal residence,
  - incorporated ?,
  - responsible capital,
  - organisation,
  - subsidiaries,
  - budget,
  - accounts,
  - etcetera.
- *Financial Service Industry Attributes, Bank:*
  - name of bank,
  - kind of bank,
  - legal residence,
  - responsible capital,
  - organisation,
  - subsidiaries,
  - budget,
  - accounts,
  - etcetera.

- *Health Care System Attributes, Hospital:*
  - name,
  - kind of hospital,
  - legal residence,
  - legal owner,
  - organisation,
  - financing,
  - budget,
  - accounts,
  - etcetera.
- *Pipeline System Attributes:*
  - name,
  - legal residence,
  - legal owner,
  - financing,
  - geography,
  - subcontractors,
  - budget,
  - accounts,
  - etcetera.

- *Transportation System Attributes:*
  - name,
  - kind of transport system[9],
  - legal residence ,
  - legal owner,
  - financing,
  - geography,
  - subcontractors,
  - budget,
  - accounts,
  - etcetera. •

• • •

[9] whether a road system or a rail/train system, or an airline, or a shipping company, etc.

3.1.3.3. Static Part Attributes

- A part attribute is static
- if that part
- never changes its value.

3.1.3.3.1. Examples

Example 12 (Static Part Attributes) Two examples:

- **Patients:**
  - name,
  - central personal registration identifier,
  - gender, and
  - birthplace.
- **Links:** length.

3.1.3.4. Dynamic Part Attributes

- A part attribute is dynamic
- if that part
- can change its value.

3.1.3.4.1. Examples

Example 13 (Dynamic Part Attributes) Three examples:

- The
  - height,
  - weight,
  - blood pressure,
  - blood sugar,
  - temperature, and
  - PMR

  of a patient are dynamic attributes.

- A hub typically can
  - connect a number of distinct links and
  - thus can attain either one of number of hub states
  - each hub state being a possibly empty set of pairs, $(\mathsf{li}_j,\mathsf{li}_k)$,
  - of not necessarily distinct link identifiers (li) of the links connected to that hub.

  The state of a hub is a dynamic attribute.
- Similarly for link states.

3.1.3.5. Indivisibility of Attributes

- Given a part of some kind (i.e., having some set of attributes), whether atomic or composite,
- one cannot "remove" an attribute from that entity
- and still retain the entity as being of that kind.

3.1.3.5.1. Examples

Example 14 (Indivisibility of Attributes) Two examples:

- One cannot remove the attribute 'height' from an entity of kind person
- and one cannot remove the attribute 'kind of transport system' from an entity of kind 'transport system'. •

3.1.4. Subparts Are Parts

- By a subpart, p', of a part, p, we thus
  - mean an entity which is not the same as the part, that is $p \neq p'$.
  - We say that a part, p', is a *proper part* of another part if it is a subpart of that part.
  - So by proper part of p and subpart of p we mean the same.

3.1.4.1. Examples

Example 15 (Sets of Hubs and Hubs – Sets of Links and Links)
From a net we observe sets of hubs and sets of links:

- A set of hubs is a value of the type sets of hubs.
- A hub is a value of type hub.
- A set of links is a value of the type sets of links.
- A link is a value of type link. •

3.1.5. Subpart Types Are Not Subtypes

- Thus, by a subpart type
  - we mean a part type
  - but the type of the subpart cannot be the same as the type of the part of which it is a subpart.

3.1.5.1. Examples

Example 16 (Part and Subpart Types) We refer to Example 15.

- Let a part be a transportation net, *n:N*.
- A subpart of a transportation net, *n:N*, is, for example, the part *hs:HS*, which is the set of all hubs of the net,
- and a hub, *h:H*, which is a part of *hs:HS*, is a subpart of *hs:HS*.
- And all these subparts are of different types, to wit: *HS* and *H*,
- and, as we shall see, *LS* and *L*, are not subtypes of type *N*. •

- By a 'union', A, of *disjoint types*, say B, C, ..., D, that is: $A{=}B|C|...|D$, we mean
  - a type whose values are either of type B or of type C or ... of type D,
  - and where every type value is of exactly one of the types B, C, ..., D.
- These types, B, C, ..., D, are subtypes of A.
- Thus subpart types are not the same as subtypes of the part of which the subpart is a proper part.
- To be consistent we rule out the possibility of defining types recursively.

3.1.6. Mereology of Composite Parts

- By the mereology of a composite part we understand
  - the number of subparts
  - of respective kinds (types)
  - of that composite entity and
  - how the subparts are related to one another.

3.1.6.1. Examples

Example 17 (Mereology of Composite parts) Five domain examples:

- *Container Line System:* A container vessel contains a number of uniquely identified bays, bays consists of a sequentially indexed sequence of (usually several) rows, and rows consist of a sequentially indexed sequence of (usually several) stacks, and stacks consists of a sequence of zero or more containers — such that access to stacks are by identity of bay, number of row, number of stack and then to the top of this possibly empty stack. Etcetera.
- *Financial Service Industry:* A bank consists of (i) a set of uniquely identified demand/deposit accounts, (ii) a set of uniquely identified savings & loan accounts, (iii) a set of uniquely identified mortgage accounts. Etcetera.

- *Health Care System:* A hospital consists of (1) a set of uniquely identified wards of kind κ_1, (2) a set of uniquely identified wards of kind κ_2, ..., and (n) a set of uniquely identified wards of kind κ_n. Etcetera.
- *Pipeline System:* A pipeline system consists of a set of units — where units a either wells, pumps, pipes, valves, forks, joins or sinks — and such that (a) a well is connected to one or more pumps, (b) a pipe is input-connected to either a pipe or a pump or a valve or a fork or a join and is output-connected to either a pipe or a pump or a valve or a fork, (c) a pump is input-connected to a pipe and is output-connected to a pipe, (d) a valve is input-connected to a pipe and is output-connected a pipe or a sink, (e) a fork is input-connected to a pipe and is output-connected to two pipes, (f) a join is input-connected to two pipes and is output-connected to a pipe, and (g) a sink is input-connected to a valve. Etcetera.

- *Transportation System:* A transport net consists of a set of hubs and a set of one or more links such that links connect exactly two distinct hubs, and thus such that hubs are connected to zero or more distinct links. Etcetera.
  - The mereology of a net can be expressed in terms of unique identifiers associated with hubs, hij, hik, ..., him, and links, lia, lib, ..., lic. •

- Mereologically two parts, e_i, e_j, may stand in the following relationships:
  - (a) either e_i is identical to e_j,
  - (b) or e_i is fully disjoint from e_j,
  - (c) or e_i is adjacent (i.e., connects) to (disjoint from, but "touches") e_j,
  - (d) or e_i is fully contained within e_j,
  - (e) or e_i partially overlaps with e_j (that is, there are "areas" of e_i which are not overlapping with "areas" of e_j).

3.1.7. Part Descriptions

- To describe an atomic part (type) it suffices to describe all the atomic part attributes:
  - its type name,
  - the attributes, and
  - its possible contribution to the mereology of "a whole":
    - own unique identification, and
    - how it 'unique identifier'-relates to other parts.
- To describe a composite part (type) it is necessary to describe these things:
  - (i) all the composite part attributes,
  - (ii) each of the subpart types (i.e., subparts), and
  - (iii) their mereology.

3.1.7.1. Examples

Example 18 (Description of An Atomic Part) We continue our example of transport nets. A link is here considered an atomic part.

- **Type Name:** link.
- **Attributes:** length, location[10], current state[11] and state space[12], etc.
- **Unique Identification:** unique Link identifier.
- **Mereology:** a pair of unique hub identifiers. •

[10] The cartographic and cadestral location of a link may, amongst other components, include, for example, a Beziér curve description of how that link "traverses" a, or the landscape.

[11] in terms of sets of pairs of distinct identifiers of connecting hubs

[12] in terms of sets of possible link states

Example 19 (Description of A Composite Part) We continue our example of transport nets. A net is here considered a composite part.

- **Type Name:** net.
- **Attributes:** name, transport kind, legal address, legal owner, sources of financing, geographical area, maintenance subcontractors, budget, accounts, etc.
- **Unique Identification:** `not applicable.`
- **Mereology:** `not applicable.`
- **Subpart Type[s]:** set of links, set of hubs. •

3.1.8. States

- By a state we understand
  - a specific set of parts
  - such that for each of these parts
  - some attributes are dynamic.

3.1.8.1. Examples

Example 20 (States) Five domain examples:

- *Container line:* container, container vessel, container terminal port.
- *Financial service industry:* bank (as a whole), account (as a subpart).
- *Health care:* hospital, ward, bed, patient.
- *Pipeline system:* well, pump, pipe, valve, pipeline.
- *Transportation:* net, link (open in one direction, open in the opposite direction, open in both directions; closed in all [two] directions), hub (open between a specific [possibly empty] set of pairs of links connected to the hub), vehicle.

3.2. Actions

- By an action we understand
  - a state change
  - resulting directly from the expected application of a specific function (one of several possible),
  - that is, the specific function was performed deliberately, on purpose.

3.2.0.1. Examples

Example 21 (Actions) We give examples from five domains.

- The examples are not proper descriptions of actions.
- We basically just give their names.
- These names — and the familiarity of the domains —
  - are such that the reader is "tricked into" thinking:
    - *"oh yes, I see; but, of course."*
  - Only a proper action description can reveal the action.

- *Container line:*
  - loading a container;
  - unloading a container;
  - moving a container from one location (say on-board a vessel) to another location (say in a container terminal port).
- *Financial service industry:*
  - open an account,
  - deposit into an account,
  - withdraw from an account,
  - obtain account statement,
  - close account.

- *Health care:*
  - admitting a person as a patient;
  - allocating a bed in a ward to a patient;
  - medicating a patient.
- *Pipeline system:*
  - opening a pump (for pumping);
  - closing a valve.
- *Transport Net:*
  - inserting a hub;
  - inserting a link;
  - removing a hub;
  - removing a link.

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3.3. Events

- By an event we understand
  - a state change
  - resulting indirectly from the unexpected application of a function,
  - that is, the specific function was performed "surreptitiously",
- Events can be characterised by a pair of (before and after) states, a predicate over these and a time.
- Events are thus like actions:
  - change states,
  - but are usually
    - either caused by "previous" actions,
    - or caused by "an outside action".

3.3.0.1. Example

Example 22 (Events) Five domain examples:

- *Container line:* A container falls overboard.
- *Financial service industry:* A bank goes bankrupt.
- *Health care:* A patient dies.
- *Pipeline system:* A pipe breaks.
- *Transportation:* A link disappears. •

3.4. Behaviours

- By a behaviour we understand
  - a set of sequences of
  - actions, events and behaviours.

3.4.0.1. Example

Example 23 (Behaviours) Five domain examples:

- *Container line:* The transport of a container
  - from it being fetched at the sender,
  - via a sequence of one or more triplets of
    - loadings onto a vessel,
    - unloading at another container terminal port
    - and possibly temporary storage at that port,
  - to its final delivery at a receiver.

- *Financial service industry*, account handling:
  - the opening of an account,
  - a sequence of
    - deposits,
    - withdrawals and
    - statements
  - to the closing of that account.

- *Health care*, patient hospitalisation:
  - the admission of a patient to a hospital,
  - initial
    - anamnese,
    - analysis,
    - diagnostics and
    - treatment plan,

    via an alternating sequence of
    - treatments (including surgical operations),
    - repeated analyses,
    - evaluations and possible reformulation of
    - diagnostics and
    - treatment plan,
  - to a final discharge.

- *Pipeline system*, simple, day-to-day operations.
  - The flow of gas (or a liquid) through a pipeline net:
    - pumped from wells,
    - fed through
      - pipes,
      - valves,
      - forks and
      - joins,
    - to leaving the net at sinks.

- *Transportation:* The movement of a vehicle along a transport net:
  - from positions at
    - ∗ hub or
    - ∗ link

    positions
  - via a sequence of zero, one or more
    - ∗ hub and
    - ∗ link

    movements,
  - to a final
    - ∗ hub or
    - ∗ link

    position.

  Example 4 (Slides 23–36) illustrated a transport behaviour. •

3.5. Discussion

- We have dealt, in some detail, with the concept of parts (Part 3.1, Slides 68–97).
- Our "corresponding" treatment of actions, events and behaviours (Parts 3.2–3.4, Slides 99–109) have been far less detailed.
- The reason for this is the following.
  - Types emerge (Part 3.1) as a means of describing parts.
  - And types are indispensable in the description of action, event and behaviour signatures (Parts 3.2–3.4).
  - Types thus form the very basis for the description of all entities.
  - And we have chosen to let the type concept emerge from our treatment of parts.

- There is another reason for Part 3.1 being somewhat more detailed than Parts 3.2–3.4.
  - When studying parts we could, relatively easily, introduce such notions as
    - atomic and composite parts,
    - attributes of these, and
    - mereologies of composite parts.
  - These notions, under some disguise,
    - can likewise be found for actions, events and behaviours,
    - but they are not that easily introduced.

End Lecture 3: Entities