Course CS4211
Software Engineering
Fall 2004

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Abstract

This document shall serve as a main document of student information for the course as listed above. It is expected that this document will appear as an NUS web page, and that it will then be updated regularly (during the fall of 2004).

Contents

1 Course Aims & Objectives

1.1 Course Aims

The course aims to introduce the student to a number of software engineering topics:

- Software development as consisting of:
  - Domain engineering,
  - requirements engineering, and
  - software design.
- Software development as resulting in documents:
  - Informative,
  - descriptive (prescriptive, specificational), and
  - analytic.
- Software development as proceeding in:

  - Phases (as for
    - (1) Domain engineering,
    - (2) requirements engineering,
    - and (3) software design);
  - stages (as for
    - (A) acquisition,
    - (B) analysis,
    - (C) modelling,
    - (D) validation & verification,

    or as for
    - (a) domain requirements,
    - (b) interface requirements
    - and (c) machine requirements,

    or, within, for example domain modelling as for
    - (i) intrinsics,
    - (ii) support technologies,
    - (iii) management & organisation,
    - (iv) rules & regulations, and
    - (v) human behaviour;

    etcetera); and
  - steps (of refinement, transformation, or posit (and prove)).
- Software development as relying on precise identification and narration of:
  - Entities,
  - functions,
  - events, and
  - behaviours.
- Software as consisting — in addition to
  - "executable code"

  and
  - installation
  - maintenance
  - user
  - disposal

  manuals — also of
  - all development documents
    - informative,
    - descriptive/prescriptive/specificational, and
    - analytical (hence of all tests, proofs and model–checks),

    of all phases, stages and steps of development
- Etcetera.

1.2 Course Objectives

The course is an under–graduate course. Hence it shies away from using formal, discrete mathematics. Instead it focuses on making sure that the course participants are able

- themselves to structure major software developments (phases, stages, designs);
- to express themselves with competence: Describing, prescribing and specifying domain properties, requirements and software designs, in clear, precise (English) language, setting up precise definitions;
- to follow and use clear methodological principles, techniques and tools;
- to thus establish models of
  - analogical,
  - iconical, and
  - analytical

  nature, whither
  - descriptive, or
  - prescriptive,

  and whither
  - extensional, or
  - intentional,

  and then full well knowing for what purposes the models are established:
  - for understanding (themselves),
  - for communication amongst developers, and/or
  - for design.
- In other words: The course has, as a main objective that of making sure that the course participant henceforth will look at software development as a highly professional, highly intellectual discipline.

2 Course Material

- Vol.3, Software Engineering — Publisher: Springer–Verlag
  Domains, Requirements, Software Design — Around January 2005
  Dines Bjørner

Postscript (.ps) and .pdf files of selected chapters will be made available to students on the NUS net. You are to download and print these selected chapters at your own expense.

You are not to read all of vol. 3.

You are only to read those pages or sections that have been highlighted in Sect. 3 below.

For an overview of the, so far 3 volume, book, pls. see:

- `http://www.imm.dtu.dk/~db/the-se-books`

Formal version: Material to be skipped

And you are to skip, on those pages and in those sections, all the framed material whose top line caption includes: Formal Version. So: You are not required to read the 'formal version' material (which mostly consists of "strange" formulas !) — but you may read it !

3 Lecture Plan

0. *Monday 2 August:* **Orientation Week**

   - Dines Bjørner will introduce the course, casually, to potential students, encouraging questions, hopefully answering these adequately, etc.
   - Venue: To be decided
   - Time: Monday morning — and to be further decided

1. *Monday 9 August:* **The TripTych of Software Engineering** Chapter 1

Lecture 1 + Assignments 1.1–.3)

Lecture Topics:

- Domain Engineering, Requirements Engineering, Software Design
  Section 1.2, Pages 7–32, minus Pages 24–29 (first 10 lines)
- Phases, Stages and Steps of Development
  Section 1.3, Pages 32–45

1. Assignment Name: TripTych Phases

Please refer to subsection 4.2. That subsection lists some 12 possible topics.

1. Please provide a 2–3 page rough sketch of what you think your chosen topic domain is. Focus initially on what, in the domain, you can point to (see, touch).
2. Then sketch $\frac{1}{2}$ page of possible requirements.
3. Finally "risk" a guess at a possible software design to implement those requirements, say 1–2 pages.

Please hand Assignment in by: Monday 16.8, 2004

Group Assignments:

- During this lecture student groups will be identified
- associated with, ie., "bound" to distinct project topics,
- and given a weekly 30–60 minute tutoring slot (See Sect. 6 on page 11).
- See also Sect. 7 on page 12.

2. *Monday 16 August:* **Documents** Chapter 2

Lecture 2 + Assignments 2.1–.2

Lecture Topics:

- Introduction, Sects. 2.1–2.2
- Informative Documents, Sect. 2.3
- Descriptive/Prescriptive/Specification Documents, Sect. 2.4
- Analytic Documents, Sect. 2.5

2. Assignment Name: Informative Documents and TOC

1. Draft a set of informative documents for a software development project which is to develop a description of the domain (that you have chosen, pls. refer to Sect. 4.2 on page 10) — 2–3 pages.
2. Draft a table–of–contents for the documents to be developed in such a project (as just mentioned) — but be prepared to revise this table–of–contents as requested in questions 5 on page 7 and 6 on page 8 — 1–2 pages.

Please hand Assignment in by: Monday 23.8, 2004

3. *Monday 23 August:* **Conceptual Framework** Part II

Lecture 3 + Assignments 3.1–.2

Lecture Topics:

- Method & Methodology, Chapter 3 — Be prepared for written examination tests
- Models & Modelling, Chapter 4 — Be prepared for written examination tests

3. Assignment Name: Rough Sketch and Terminology

1. Develop 2–3 pages of rough sketch description of the topic domain (Cf. Sect. 4.2). Describe what you can point to, the "things" (entities) you can perceive of in that domain, what you can see "happening" to those things (functions, events, behaviours). Be prepared, later, to revise this description.
2. Identify, and list and very briefly try define, alphabetically, as many professional terms of the topic domain. Be prepared, later, to revise (edit, and extend) this terminology - 1–2 pages.

Please hand Assignment in by: Monday 30.8, 2004

4. *Monday 30 August:* **Descriptions: Theory & Practice** Part III

Lecture 4 + Assignments 4.1–.3)

Lecture Topics:

- Phenomena & Concepts, Chapter 5
- On Defining and On Definitions, Chapter 6
- Jackson's Description Principles, Chapter 7

4. Assignment Name: Description Theory

1. Entities, Functions, Events and Behaviours

   Identify, in your previously reported rough sketches, or some new, entities (approximately 1 page), functions (approximately 1 page), events and behaviours (approximately 2 pages) — as you perceive of them in the topic domain.

2. Definitions

   Provide definitions for some example composite entities, for some functions, and for some behaviours (1 page).

3. Designations and Recognition Rules

   Identify which entities, etc., can be designated, which must be defined, and which descriptions may be refuted ($\frac{1}{2}$ page each: Designations, definitions, refutable assertions).

Please hand Assignment in by: Monday 6.9, 2004

DOMAIN ENGINEERING Part IV

5. *Monday 6 September:* **Stake Holders and Facets (1 of 2)**

Lecture 5 + Assignments 5.1–.3)

Lecture Topics:

- Overview, Chapter 8
- Domain Stake Holders, Chapter 9
- Domain Facets (1 of 2) Chapter 11, Sect. 11.1
  - Intrinsics, Sect. 11.2
  - Business Process Engineering, Sect. 11.3

5. Assignment Name: Domains: Stake Holders, Intrinsics and BPE

1. Identify all potential stake holders of your topic domain ($\frac{1}{2}$ page).
2. Narrate, ie., systematically describe some intrinsics of your topic domain (1–2 pages).
3. Narrate, ie., systematically describe some business processes of your topic domain (1–2 pages).

Please hand Assignment in by: Monday 13.9, 2004

6. *Monday 13 September:* **Facets (2 of 2)**

Lecture 6 + Assignments 6.1–.5

Lecture Topics:

- Domain Facets (2 of 2) Chapter 11
  - Support Technologies, Sect. 11.4
  - Management & Organisation, Sect. 11.5
  - Rules & Regulations, Sect. 11.6
  - Human Behaviour, Sect. 11.8

6. Assignment Name: Further Domain Facets

1. Narrate, ie., systematically describe some Support Technology facets of your topic domain ($\frac{1}{2}$ page).
2. Narrate, ie., systematically describe some Management & Organisation facets of your topic domain ($\frac{1}{2}$ page).
3. Narrate, ie., systematically describe some Rules & Regulations facets of your topic domain

($\frac{1}{2}$ page).

4. Narrate, ie., systematically describe some Human Behaviour facets of your topic domain ($\frac{1}{2}$ page).
5. Revise the table–of–contents for the set of development documents being developed. We refer also to the earlier question, 2 on page 5, and to a later question, 6 on the following page.

Please hand Assignment in by: Monday 20.9, 2004

Monday 20 September: **Mid–semester Break**

- Dines Bjørner will be available for important tutoring during all week.

REQUIREMENTS ENGINEERING Part V

7. *Monday 27 September:* **Overview and BPR**

Lecture 7 + Assignment 7.1

Lecture Topics:

- Overview, Chapter 17
- BPR: Business Process Requirements, Sect. 19.2

7. Assignment Name: BPR: Business Process Re–engineering

1. Identify and narrate, ie., systematically describe some Business Process Requirements for your topic domain (2 pages).

Please hand Assignment in by: Monday 4.10, 2004

8. *Monday 4 October:* **Domain Requirements**

Lecture 8 + Assignment 8.1(a)–(e)

Lecture Topic:

- Domain Requirements, Sect. 19.3

8. Assignment Name: Domain Requirements

Identify and narrate, ie., systematically describe some Domain Requirements for your topic domain. Decompose your domain requirements into:

1. Projection ($\frac{1}{4}$ page),
2. determination ($\frac{1}{4}$ page),
3. instantiation ($\frac{1}{4}$ page),
4. extension ($\frac{1}{4}$ page), and
5. fitting ($\frac{1}{4}$ page).

Please hand Assignment in by: Monday 11.10, 2004

9. *Monday 11 October:* **Interface Requirements**

Lecture 9 + Assignments 9.1–.2(a)–(f)

Lecture Topic:

- Interface Requirements, Sect. 19.4

9. Assignment Name: Interface Requirements

1. Identify and narrate, ie., systematically describe some Shared Phenomena & Concepts for your topic domain ($\frac{1}{2}$ page).
2. Identify and narrate, ie., systematically describe some Interface Requirements for your topic domain. Decompose your interface requirements into:
   (a) Shared Data Initialisation ($\frac{1}{3}$ page),
   (b) Shared Data Refreshment ($\frac{1}{3}$ page),
   (c) Computation Data & Control Interface ($\frac{1}{3}$ page),
   (d) Man–Machine Dialogue ($\frac{1}{3}$ page),
   (e) Man–Machine Physiological Interface ($\frac{1}{3}$ page), and
   (f) Man–Machine Physiological Dialogue ($\frac{1}{3}$ page).

Please hand Assignment in by: Monday 18.10, 2004

10. *Monday 18 October:* **Machine Requirements**

Lecture 10 + Assignments 10.1–.6

Lecture Topic:

- Machine Requirements, Sect. 19.5

10. Assignment Name: Machine Requirements

1. Identify and narrate some Performance Requirements for your topic domain ($\frac{1}{4}$ page).
2. Identify and narrate some Dependability Requirements for your topic domain ($\frac{1}{4}$ page).
3. Identify and narrate some Maintenance Requirements for your topic domain ($\frac{1}{4}$ page).
4. Identify and narrate some Platform Requirements for your topic domain ($\frac{1}{4}$ page).
5. Identify and narrate some Documentation Requirements for your topic domain ($\frac{1}{4}$ page).
6. Revise the table–of–contents for the set of development documents being developed. We refer also to the earlier questions, 2 on page 5, and 5 on the preceding page.

Please hand Assignment in by: Monday 25.10, 2004

SOFTWARE DESIGN Part VI

11. *Monday 25 October:* **Software Architecture Design**

Lecture 11 + Assignment 11.1

Lecture Topic:

- Software Architecture, Chapter 26: Skip all formulas

11. Assignment Name: Software Architecture

1. Suggest, diagrammatically and textually a software architecture: Processes and communications (the latter in terms of types of messages and their effect) (2–3 pages).

Please hand Assignment in by: Monday 1.11, 2004

12. *Monday 1 November:* **Component Design**

Lecture 12 + Assignment 12.1

Lecture Topic:

- Component Design, Chapter 27: Skip all formulas

12. Assignment Name: Components

1. Single out three components, ie., three processes linked by communication paths, and narrate the data structures and the procedures (objects, functions, methods) of those components (1–2 pages).

Please hand Assignment in by: Monday 22.11, 2004

13. *Monday 8 November:* **Acquisition, Analysis, Validation and Verification**

Lecture 13 + Assignments 13.1

Lecture Topic:
This material will not be exemplified in reports.
But it is good for written examination tests.

- Acquisition: Chapters 12 (Domains) and 20 (Requirements)
- Analysis: Chapters 13 (Domains) and 21 (Requirements)
- Validation & Verification: Chapters 14 (Domains), 22 (Requirements), and Sect. 29.5 (Software Design)

Monday 22 November: **Final Assignment report due Monday 22 November**

4 Course Work

4.1 General

- Class is encouraged to compose themselves into n groups, g_i, of p_i students each — such that $\Sigma_{i=1}^{p} p_i = C$, where C is class size.
- We suggest group sizes of around 6–8 students each.
- Each group is given an assignment over which they will, as a group, each week deliver a 3–5 page report.
- The weekly reports partially fill in, ie., contribute to the final report — which can thus be expected to be some 30–50 pages long.
- The weekly and thus the final report is in English, no mathematics — unless you insist ! Meaningful drawings are OK, but be aware that the lecturer, me, Dines Bjørner, is rather particular wrt. (with respect to) what constitutes a 'meaningful' drawing.

4.2 Specific Assignment Topics

1. *What is Administrative Forms Processing ?* (NUS, anyone ?)
2. *What is an Airport ?* (Changi, anyone ?)
3. *What is Air Traffic ?* (Changi etc., anyone ?)
4. *What is a Container Harbour ?* (Singapore, anyone ?)
5. *What is a Document System ?*
6. *What is Freight Logistics ?* (Singapore, anyone ?)
7. *What is a Financial Service System ?* (Singapore, anyone ?)
8. *What is a Hospital ?* (NUS Hospital, anyone ?)
9. *What is a Manufacturing Company ?*
10. *What is the Market ?* (in preparation for an/the $\mathcal{E}$–Market)
11. *What is a Metropolitan Area Tourism Industry ?* (Singapore, anyone ?)
12. *What is a Railway System ?* (MRT ?)

Section 7 will bring more details.

4.3 Assignments

- Weekly assignments relevant to either of the above selections has already been posted above, under the lecture plan, and will be posted in respective chapters' "Problem/Exercise" sections.
- Pls. refer to problem assignments — when answering — by lecture number "dot" problem number: *L.P.*
- These assignments, and their expected answers, are arranged (ordered, etc.) so as to eventually guide the student through to a meaningful final report, one that is reasonably representative of a proper, commercial, large scale, real–life, advanced development.

5 Examination

There will be two forms of examination:

- **Written, 2 Hour, "Closed Book" Test.**
- **Report Evaluation.**

Each form of examination "counts" 50%.

5.1 Written, 2 Hour Test

- The written, 2 hour test is a **closed book** test.
- You will be asked a number of questions. Each question is designed to test that you have understood the essence of one of the topics covered in the lectures.
- The questions will thus cover areas of the lectures not naturally coverable by the assignment reports. In the lectures, the lecturer will point out such typical written examination questions !
- The test questions complement those asked to be solved in the assignments.

5.2 Assignment Reports – and Assignment Report Evaluation

- Each group submits one assignment report each week.
- There will be 12 assignment reports.
- For the final report you are, please, to submit all "early" reports (possibly edited, as per your decision) as well as the answers to the last, posed question (12.1).
- The final report will resemble major parts of a proper, full scale, real–life, commercial development document, one that can be read by itself, ie., free–standing.
- All ("early" and final) report front pages will state:

```
Course Name:
Course Number:
Weekly Report Serial Number: #i (i=1,...,12), Date:
Assignment Topics:
  As stated above, in the frame, after each lecture's "Assignment Name"
Group members:
  Name 1, E-mail #1,
  Name 2, E-mail #2,
  ...
  Name i, E-mail #i,
```

- The final report will be all the previous (ie., early) reports + the last report (formulated 8 Nov., 2004). You are free to update, edit, revise, that is: Improve earlier reports.
- The lecturer will evaluate each assignment report, for the next week, only if the group meets up for tutoring in the week of the 'hand in'.
- Please use text processing system with adequate cross–referencing and indexing facilities. We suggest (that you learn and/or use) LaTeX.
- The lecturer's final assessment will be based on some "mix" of early and final reports. Improvements will thus be notes — as will ability to turn in meaningful early reports.
- The lecturer will make the final assessments of both written tests and group report at course end, and will post these evaluations by December 4 to respective groups.

6 Tutoring

- The lecturer, Dines Bjørner, expects to help, individually, each group, some 30–60 minutes each, each week.
- That is: Dines Bjørner offers this — by offering a 30 minute slot, weekly, the first six week Tuesdays–Fridays (9. Aug. –18. Sept.), and a 60 minute slot, each week, the Tuesdays–Fridays of 24. Sept. – 5. Nov., and in the time frames:
  - Tuesday: 9–11:30, 13–16
  - Wednesday: 9–11:30, 13–16
  - Thursday: 9–11:30, 13–16
  - Friday: 9–11:30, 13–16
- The lecturer expects around 12 groups, and initially will only "talk" with a group 30 minutes per week — to initialise them, to get them going, to give the group members verbal examples of what he expects them to write in the next weekly report.

- At the same time as a group tutoring half or full hour, the lecturer will assess that week's assignment report by the tutored group.
- So, if you have a voice recorder, bring one, and you can preserve what Dines Bjørner says, and write off from that !
- Dines Bjørner will not be available during the following two periods:
  - Monday August 23 afternoon — Sunday August 29 all day.[1]
  - Friday September 17 pm to Sunday September 26.[2]
  - Monday November 8 afternoon — Thursday November 18 all day.[3]

7 More on Course Topics

1. *What is Administrative Forms Processing ?*

   Typically enterprises base part of their day–to–day operations (especially administration) on a small set of forms: *Employment forms:* Application, employment offer, offer acceptance or rejection, work assignment form, form(s) for reporting sick leave, leave with, or without pay, etc., termination or notification form, etcetera; *procurement forms:* Product or service inquiry, Product or service offers, requisition, receipt form, inspection (acceptance or rejection) form, payment form, etcetera. Each form basically contain preformatted fields, to be 'filled in', partially or fully. Each such partially 'filled in' form may undergo several 'rounds' of 'filling in' and possible, where needed, approvals (signatures). Etcetera.

2. *What is an Airport – and what Software Do You Want and Get ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with the flow of people (passengers), material (fuel, catering, luggage), aircrafts, information (passenger, luggage, catering, fuel, servicing, etc., information), and control in an airport.

3. *What is Air Traffic – and what Software Do You Want and Get ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with the movements (start–up, take–off, flight, preparation for landing, possible holding (in holding areas), touch down and taxiing) of aircrafts — under the monitoring and "control" by ground, terminal, area and continental air traffic control towers.

4. *What is a Container Harbour – and what Software Do You Want and Get ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with the flow of ships and cargo, into and out from a container harbour: Ships arriving at a container harbour, ships having, possibly, to anchor for container quay place, ships unloading and loading containers, ships being detained for customs, illegal cargo, or lack of seaworthyness reasons in a harbour, ships cleaning their fuel tanks in a harbour, and ships leaving harbour.

5. *What is a Document System ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with documents: Their creation as originals, at a certain

[1] DB is chairing a Topical Day Session, August 26, at the IFIP World Computer Congress 2004, at Toulouse, France: http://www.wcc2004.org/congress/topical_days/top11.htm.

[2] DB is planning, subject to approval, to visit UNU–IIST, the United Nations' University's International Institute for Software Technology at Macau, SAR, near Hong Kong: http://www.iist.unu.edu.

[3] DB is General Chair of the Intl. Conf. on Formal Engineering Methods, ICFEM'04, Seattle, Washington, USA: http://research.microsoft.com/conferences/icfem2004.

time and location, their placement with (allocation to) people or file cabinets, their copying (whereby unique, distinct copies are made, with no two copies of the same document being the same due to their necessarily being copied at different times), their editing (whereby the document which is being edited — whether an original, or a copy, or a version — becomes a version of the document it was "edited from"), their movement (ie., transfer from persons or file cabinets to (other) persons or (other) file cabinets, all necessarily having different locations — or their movement because the person with whom a document is associated is carrying that document "around"), or their shredding.

6. *What is Freight Logistics – and what Software Do You Want and Get ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with (1) people (senders) inquiring with logistics firms about and actually sending or receiving freight transports; (2) with logistics firms arranging such transportation with trucking companies, with freight train operators, with ship owners, and with air cargo companies — as well as logistics firms interacting with trucking and freight train depots, harbours and airports; with (3) trucks, trains, ships and aircrafts unloading and loading freight at depots, harbours and airports, etc. A central concept: That of a way bill (or a bill of lading) directs freight from point of origin via intermediate hubs (depots, harbours, airports), to final destination.

7. *What is a Financial Service System – and what Software Do You Want and Get ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with people, customers, using banks, insurance companies, stock brokers and portfolio managers. Thus also the entities, functions, etc., of these phenomena need be described. Of special interest is transfers of securities instruments between banks, insurance companies, stock brokers, the (assumed one) stock exchange, and portfolio managers.

8. *What is a Hospital – and what Software Do You Want and Get ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with the flow of patients, visitors and health–care workers, of materials (beds, medicine, etc.), information (patient medical records with update information on clinical tests, X–rays, ECGs, MR Scans, CT scans, etc.), and control in a hospital. Thus patient treatments, as a process, and its interaction with other hospital processes need be narrated.

9. *What is a Manufacturing Company – and what Software Do You Want and Get ?*

   Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with the flow of orders into, and deliveries from a manufacturing company, as well as the flow of materials (parts), equipment (trucks, conveyor belts, etc.), information (sales orders, production orders, etc.), and control among and within the various departments of a manufacturing enterprise: Marketing, sales and service, design, production floor (machines [lathes, saws, mills, planers, etc.] and their in– and out trays, delivery trucks, etc.), parts and products warehouses, etc.

10. *What is the Market – and what Software Do You Want and Get ?*

    Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with customers inquiring about, ordering, getting delivered, returning (rejecting), accepting and paying for, merchandise — with, from, and to retailers, who again perform similar actions with wholesalers, who again perform similar actions with producers, and where distribution companies may be involved in deliveries from producers to wholesalers to retailers to consumers.

11. *What is a Metropolitan Area*[4] *Tourism Industry – and what Software Do You Want and Get ?*

    Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with the inquiry, arrival, flow and departure of people (tourists, conference–goers, business people) about, to, within and from a metropolitan area: Between airports and hotels, and between hotels, restaurants, shops, museums, theatres, parks, historic sights, nature spots, etc. Inquiry about and reservations of hotel rooms, restaurants (tables), theatres (tickets), the inquiry and buying of transport cards, what to buy, planning of shopping "spree" (itinerary), etc. — all are part of what a visitor to a metropolitan area undergoes, including possible visits to the dentist, medical doctor, or hospital emergency room.

12. *What is a Railway System and what Software Do You Want and Get ?*

    Domain descriptions of this topic shall identify and describe the entities, functions upon, and events & behaviours in connection with the rail net (lines and stations), time tables, train traffic, passengers inquiring, buying tickets, canceling (ie., using) tickets, etc. The lines and stations consists of rail units, have signals, etc. Thus railway system personnel despatch and reschedule, maintain (clean, repair, etc.) trains, and personnel are rostered (ie., assigned to train duties, etc.), etc.

For respective of the above topics similar prescriptions, respectively specifications are to be made of requirements and software design.

8 Lecturer's CV

The curious student may wish to inspect:

- `http://www.imm.dtu.dk/~db/biodata`

for biographical data about the lecturer.

- `http://www.imm.dtu.dk/~db/the-se-books`

for information about the course text book.

- `http://www.RailwayDomain.org/`

for information about a worldwide railway system domain R&D project instigated and headed by Dines Bjørner.

- `http://fm.colognet.org/`

for information about formal methods (the CoLogNET[5] part headed by Dines Bjørner).

And:

- `http://www.imm.dtu.dk/~db`

as the main entry to info related to the lecturer.

[4] Such cities as Singapore, Macau, Hong Kong, London, New York, Tokyo, Paris, etc. can be said to be 'Metropolitan Areas'.

[5] http://aludra.dbai.tuwien.ac.at/portal1/index.php