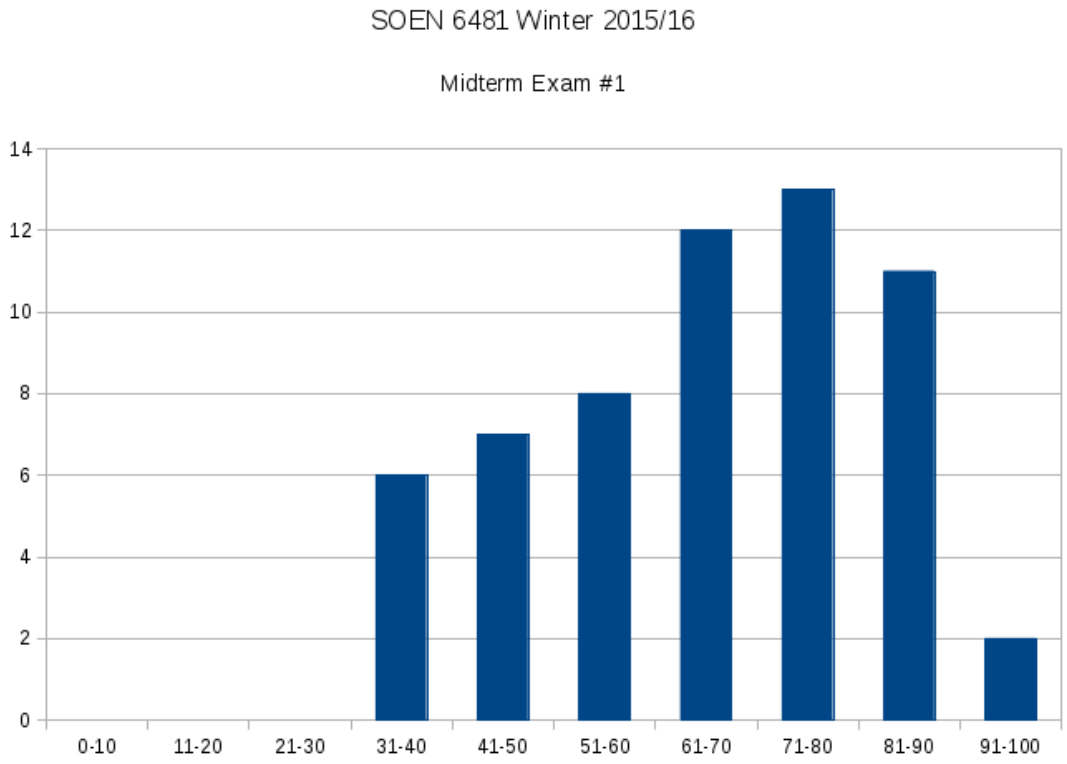
SOEN 6481 Software Systems Requirements Specification

Winter 2015/16

Midterm Exam I – Solutions

Name: _____ Total Points:

ID: _____ _____ / 40



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Average	2.65	0.33	3.31	0.78	2.83	0.85	4.91	5.42	5.25	26.31
Percent	88.42	33.05	82.63	77.97	47.18	84.75	61.33	67.69	65.57	65.78

(3pts) **1.** Provide *brief* answers to the following questions.

3 pts

1. Name three different *requirements elicitation* techniques:

   (1) **Interviews**

   (2) **Questionnaires**

   (3) **Repertory Grids**

2. Name three different *non-functional requirement (NFR)* types:

   (1) **Security**

   (2) **Usability**

   (3) **Maintainability**

3. Name three different *defects* that can occur in a requirements document:

   (1) **Ambiguity**

   (2) **Contradiction**

   (3) **Overspecification**

Solution. Above are some examples for correct solutions. For other possible answers, please refer to the NFR taxonomies, elicitation techniques and defects listed in the van Lamsweerde and Leffingwell/Widrig books, as well as the software engineering process models covered in Lecture #02.

Marking. 1 marks for each sub-question (all three answers must be correct to receive the full mark, $-\frac{1}{2}$ marks off for each missing or wrong answer).

(1pt) **2.** How is *risk* handled in each of the following lifecycle models? Provide a brief (one-sentence) explanation for each:

1 pt

1. Waterfall Model

   Explanation: The Waterfall model has no risk management.

2. Spiral Model

   Explanation: The Spiral model performs a risk analysis at the begining of each iteration and develops a prototype based on the highest risk(s).

3. Unified Process

   Explanation: The UP performs a risk analysis in each iteration, Use Cases with the highest risk are selected for implementation.

Discussion. This question is about software process models (Lecture #02) and their risk management (Lecture #05).

Marking. For a fully correct answer in the Spiral and UP part, you had to state (1) that risk analysis is performed at each iteration; and (2) what is done based on this risk analysis – i.e., developing a prototype in case of the Spiral model and scheduling high-risk UCs in case of the UP (note that the question is about *how* the risk is handled in these process models – just doing a risk analysis, without taking any action based on it, does not make the risks magically disappear!).

(4pts) **3.** The following questions are about the *Unified Process* (UP). For each question, there is at least one correct answer. There might be multiple correct answers, in that case you need to check all of them to get full marks.

4 pts

Where in the UP can *functional requirements* (FRs) be documented?

- [x] As part of the Use Case model
- [x] As part of the Supplementary Specification
- [ ] As part of the Glossary
- [ ] FRs are not handled in the UP

Based on which criteria are *Use Cases* (UCs) selected for the next *iteration*?

- [ ] Newest UCs
- [x] UCs with the highest risks
- [ ] Oldest UCs
- [ ] Longest UCs
- [x] UCs with the highest value
- [ ] UCs are not handled in iterations

How are *non-functional requirements* (NFRs) handled in the UP?

- [ ] NFRs are modeled as Use Cases
- [ ] NFRs are described in the Glossary
- [x] NFRs go into the Supplementary Specification
- [ ] NFRs are not handled in the UP

What is the outcome of an *iteration* in the UP?

- [ ] Protoype that will be discarded in the next iteration.
- [ ] Requirements specifications (SRS) only
- [x] Tested, executable subset of the final system.
- [ ] There is no defined outcome

Marking. $-\frac{1}{2}$ per question for each missing or erronous selection.

(1pt) **4.** Consider the following requirements specification statement:

1 pt

The system must be fast enough to handle peak production throughput.

Do you see any defects in this statement? *(Check only one answer)*

- [ ] This is obviously "Noise"
- [x] Yes, "Unmeasurability"
- [ ] Sure: "Poor Modifiability"
- [ ] I detect "Inadequacy"
- [ ] No, that's a clear and precise statement.

Marking. 1 mark for the correct answer.

(6pts) **5.** Consider the following requirements statements that you elicited for a library book loan system:

6 pts

- S1: "Users can search for books by title and author"
- S2: "The maximum loan period is 4 weeks"
- S3: "A user can freely select the loan period"
- S4: "The loan period must be shorter than the maximum loan period"

Your task is to detect requirements overlaps and conflicts and document them using an *interaction matrix*.

(a) (3 pts) Document the detected overlaps and conflicts in the interaction matrix below and compute the values for the total row and column:

Statement	S1	S2	S3	S4	Total
S1	0	0	0	0	0
S2	0	0	1	1000	1001
S3	0	1	0	1000	1001
S4	0	1000	1000	0	2000
Total	0	1001	1001	2000	4002

Here, S_{ij} =

- 1: conflict
- 0: no overlap
- 1000: no conflict

(b) (1 pt) Compute the *total* number of conflicts: **2**

as well as the *total* number of non-conflicting overlaps: **4**

(c) (1 pt) Name two different *conflict resolution strategies*:

(1) **Drop lower-priority statements**

(2) **Weaken conflicting statements**

(d) (1 pt) Apply one of the two strategies from (c) to this example to resolve a conflict:

(1) **Remove requirement S3**
(2) **Change S2 to "The maximum loan period is 4 weeks unless the user has special permission"**

Solutions. For (a), see the table above. Notation: S_{ij} = 1: conflict, 0: no overlap, 1000: overlap (but no conflict).

For (b), you had to compute the number of conflicts and non-conflicting overlaps as discussed in Lecture #6, by integer division: $4002 \text{ div } 1000 = 4r2$

For (c), you had to name two strategies for generating conflict resolutions that were discussed in the evaluation lecture (see Lecture #6). You then had to apply one of these two strategies to resolve the conflicts that you identified in (a); the solution shows one possible example for a successful conflict resolution.

Marking. For (a), 2 points for correct table entries, $-\frac{1}{2}$ marks off for each error. Note that the table must be filled in completely and it must be symmetric. For (b), $\frac{1}{2}$ marks for each correct number of conflicts and overlaps. For (c), $\frac{1}{2}$ marks for each correct strategy and for (d), 1 marks for a correct application of one of the strategies from (c) to the provided statements S1–S4, so that the conflict identified in (a) is resolved.

(1pt) **6.** In the quantitative reasoning technique for evaluating options, a Weight(c) is assigned to to each evaluation criterion c and a Score(o, c) is assigned to each option o for c. Then, we can compute the totalScore(o) for an option o as:

1 pt

$$\text{totalScore}(o) = \sum_c (\text{Score}(o, c) \times \text{Weight}(c))$$

Based on the result, which option do you select for a project? *(Check only one answer)*

- ☐ The one with totalScore = 1
- ☑ The one with the HIGHEST totalScore
- ☐ It's a trick question, I don't use the totalScore for selecting options!
- ☐ The one with totalScore (closest to) AVERAGE
- ☐ The one with the LOWEST totalScore

Marking. 1 mark for the correct answer.

(8pts) **7.** Your task is to prioritize a number of requirements based on the *Analytic Hierarchy Process* (AHP) method.

8 pts

Using the following scale throughout this question:

1 contributes equally	7 contributes very strongly more
3 contributes slightly more	9 contributes extremely more
5 contributes strongly more	

(a) (2 pts) You obtained the *relative value* contributions for the objectives from your stakeholders:

- "Produce optimal date" *contributes slightly more* than "Handle preferred locations"
- "Parameterize conflict resolution strategy" *contributes strongly more* than "Produce optimal date"
- "Parameterize conflict resolution strategy" *contributes very strongly more* than "Handle preferred locations"

Fill the values in the table below:

Objectives	Produce optimal date	Handle preferred locations	Parameterize conflict resolution strategy
Produce optimal date	1	3	$\frac{1}{5}$
Handle preferred locations	$\frac{1}{3}$	1	$\frac{1}{7}$
Parameterize conflict resolution strategy	5	7	1

(b) (2 pts) You also obtained the *relative cost* contributions for the objectives from your team:

- "Produce optimal date" *contributes very strongly more* than "Parameterize conflict resolution strategy"
- "Handle preferred locations" *contributes slightly more* than "Produce optimal date"
- "Handle preferred locations" *contributes strongly more* than "Parameterize conflict resolution strategy"

Fill the values in the table below:

Objectives	Produce optimal date	Handle preferred locations	Parameterize conflict resolution strategy
Produce optimal date	1	$\frac{1}{3}$	7
Handle preferred locations	3	1	5
Parameterize conflict resolution strategy	$\frac{1}{7}$	$\frac{1}{5}$	1

⇒ ***Continued on next page!***

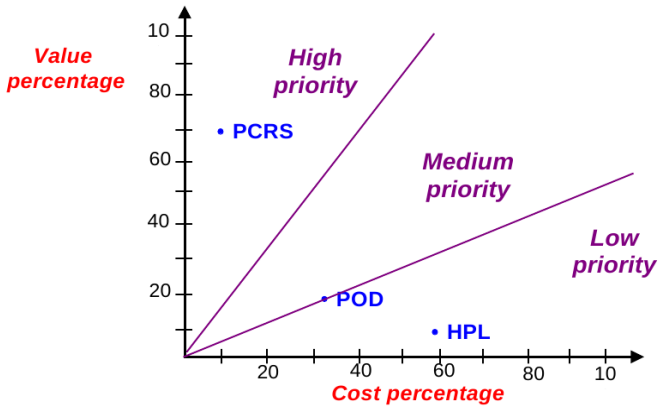
(c) (3 pts) Now compute the relative contributions (cost, value) using the formulas:

$$\text{Contrib}(R_i, crit) = \sum_j R'_{ij}/N$$

$$\text{Where } R'_{ij} = R_{ij}/\sum_i R_{ij}$$

Objectives	Relative value	Relative cost
Produce optimal date	0.19	0.33
Handle preferred locations	0.08	0.59
Parameterize conflict resolution strategy	0.72	0.08

(d) (1 pt) Enter the computed results into the cost-value graph below. Clearly label each value with the corresponding objective (POD, HPL, PCRS):



Solutions. See above. Note: Different exams had slightly different table values; the solution shown here corresponds to one of these versions.

For (a) and (c), you simply had to insert "1" for the diagonal values, and the inverse ($1/R_{ij}$) for the values across the diagonal. For (b) and (d), you just had to apply the provided formulas to compute the normalized values and relative cost/value columns.

Marking. For (a) and (b), 2 marks for correctly filled-in tables, $-\frac{1}{2}$ marks off for each error. For (c), $\frac{1}{2}$ marks for each correct value. For (d), you simply had to plot the three calculated (cost, value) pairs into the graph, for which you received one point, as long as the plot was reasonably close to the computed values.

Discussion. AHP was covered in Lecture #05 and a corresponding worksheet, as well as exercise #3. All formulas were provided, so you essentially only had to translate the textual statements to table entries and perform the calculations.

(8pts) **8.** You are the requirements engineer for the *"Wings of the World"* travel agency system. Based on the following description of the *Change Seat* use case, answer the questions below:

8 pts

1. This use case begins when the traveler indicates to the system that he/she wishes to change his/her seat assignment.
2. The system acknowledges the request of the traveler and requests booking information.
3. The traveler provides the flight booking information to the system.
4. The system verifies the traveler's eligibility for a seat change.
5. The system looks up the flight that matches the traveler's booking information in the airline's reservation system and shows the available seats to the traveler.
6. The traveler selects a new seat and indicates the chosen seat to the system.
7. The system confirms the new seat assignment to the traveler and releases the previous seat assignment.

(a) (1 pt) What level does this use case correspond to?

- ☐ Summary goal level
- ☑ User-goal level
- ☐ Subfunction level
- ☐ This is not a proper use case!

(b) (2 pts) Identify 2 *actors* in this use case and give a brief description (3–5 words) for each:

- **Actor 1:** Name: Traveler
  Description: Primary actor using the system for travel management
- **Actor 2:** Name: Airline Reservation System
  Description: External system maintaining reservation information

(c) (2 pts) Consider 2 *stakeholders* for this system that are **not** listed as actors above and give a brief description (3–5 words) for each:

- **Stakeholder 1:** Name: System Administrator
  Description: Reponsible for installing, updating, and maintaining the system
- **Stakeholder 2:** Name: System Developer
  Description: Software Engineer responsible for system development

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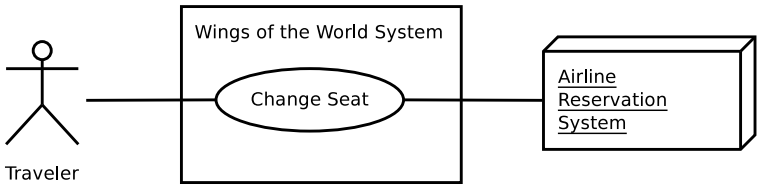
(d) (2 pts) Write two extensions (alternative scenarios) for the "Change Seat" use case. Provide the step number in the main success scenario where the extension occurs, as well as a brief description:

1. **4a** : **Traveler not eligible for seat change**

2. **5a** : **No other seats available**

(e) (1 pt) Draw a UML use case diagram for the "Change Seat" use case:



Solutions. See above for a possible solution. For (a), you had to identify that the use case is user-goal level. For (b), you had to identify the two actors within the use case steps. For (c), you had to define two stakeholders that are conceivably involved in the project, other than the two actors from (b). For (d), you had to identify two steps in the use case description where an extension is possible; the solution shows the probably most obvious extensions for this use case. Finally, for (e), you simply had to show the use case diagram including your two actors from (b) (in particular, you were not supposed to show any other use cases, since the question clearly asked for a diagram for the 'Change Seat' use case only).

Discussion. This question targets requirements specification with use cases, which was covered in Lecture #7.

Marking. For (a), 1 mark for the correct answer. For (b) and (c), 1 mark for each correct actor/stakeholder with matching description. For (d), 1 mark for each reasonable extension, together with the corresponding step in the use case description. For (e), 1 mark for the correct use case diagram showing your actors from (b).

(8pts) **9.** Consider the following requirements statements for a software system:

8 pts

1. If a user has database access, then he can save new records.
2. If a user cannot save new records, then the system is in debug mode.
3. If the system software is in debug mode, then no user is permitted to access the database.

(a) (2 pts) Translate these requirements into propositional logic, using the abbreviations:
P: *the system software is in debug mode*
Q: *user has database access*
R: *user can save new records*

1. $Q \rightarrow R$
2. $\neg R \rightarrow P$
3. $P \rightarrow \neg Q$

(b) (1 pt) Show that the three requirements are *consistent*:
Solution: We have to find a *model* for the requirements set

$$S = \{r_1, r_2, r_3\} = r_1 \wedge r_2 \wedge r_3.$$

One possible model is $P = F, Q = T, R = T$, so the requirements are consistent.

(c) (1 pt) Consider a requirement represented as a propositional logic formula r that is *valid* (written $\models r$). This means *(check only one answer)*:

- ☑ the requirement is *redundant*
- ☐ the requirement is *illogical*
- ☐ the requirement is *ambiguous*
- ☐ the requirement is *inconsistent*
- ☐ the requirement is *unsatisfiable*
- ☐ nothing – has no particular impact for the requirements specification

⇒ ***Continued on next page!***

(d) (4 pts) Now consider the following requirements specification in propositional logic:

1. $P \vee E$
2. $P \rightarrow B$
3. $E \rightarrow \neg U$
4. U

Using a *refutation proof by resolution*, show that the statement

5. B

logically follows from the requirements:

Step 1. Translate all requirements into Conjunctive Normal Form (CNF):

1. $P \vee E$
2. $\neg P \vee B$
3. $\neg E \vee \neg U$
4. U

Step 2. Negate the goal and transform it into CNF:

- $\neg B$

Step 3. Provide a **Refutation Proof** by resolution (note: you must show the results of each proof step, i.e., each application of the resolution rule, not just the end result):

Solution: We need to proof E. The question asked for a refutation proof by resolution, hence we must show that $S = \{r_1, r_2, r_3, r_4, \neg E\} = r_1 \wedge r_2 \wedge r_3 \wedge r_4 \wedge \neg E$ leads to a contradiction. For the resolution proof, we need to translate all requirements into CNF: 1., 4., and the goal are already in CNF; 2. translates into $\neg P \vee B$ and 3. into $\neg E \vee \neg U$. We can now apply the resolution rule on these clauses to find a contradiction:

$$\dfrac{\dfrac{\dfrac{\dfrac{\neg B \quad \neg P \vee B}{\neg P} \quad P \vee E}{E} \quad \neg E \vee \neg U}{\neg U} \quad U}{\square}$$

Solutions. See above. Note that different exams had slightly different requirements statements and abbreviations; the solution shown here corresponds to one of these versions.

Discussion. This question covers the formal specification of requirements using propositional logic (Lecture #9).

Regarding (c), in formal specification with propositional logic, the requirements are joined by a logical *and*, hence $S = \{r_1, r_2, \ldots, r_n\} = r_1 \wedge r_2 \wedge \ldots \wedge r_n$. So, if one requirement is always true, it can be safely removed from the specification S, hence it is redundant.

Marking. For part (a), -1 off for each major error in the translations.

For part (b), 1 pt. if you stated that the requirements set is consistent because it has a model and clearly showed a correct model (truth value assignment to the variables).

For part (c), 1 pt. for the correct answer.

For part (d), $-\frac{1}{2}$ pts. off for each error in the CNF translations, an error the negated goal, as well as each error or missing resolution step in the proof (which must end by showing a contradiction). No marks were given if you did not provide a *proof by resolution*, as was asked in the question.

— End of Exam Solutions —