

# Exam Software Architecture

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6 November 2017, 17:00 – 20:00

This closed-book exam consists of 4 questions on 6 pages. The 7<sup>th</sup> page can be used for answering question II.A. Please check first whether you have properly obtained **all** pages.

Some tips:

- Answer on the separate exam papers.
- Disengage the last page for answering question II.A.
- Read carefully the question before you start answering!
- Be clear and concise in your answers
- Reread your answers to check whether you really answered the question posed!
- Write clearly!
- Once finished, fold all papers together and hand in your work.

Good luck with the exam!

| Question | Max. points | Awarded points |
|----------|-------------|----------------|
| 1        | 25          |                |
| 2        | 25          |                |
| 3        | 30          |                |
| 4        | 20          |                |
| Total:   | 100         |                |
| Grade:   | Total / 10  |                |

## I. Basic concepts (25 points)

We consider software architecture to be “the set of structures needed to reason about the system, which comprises software elements, relations among them, and properties of both” (Bass et al, 2012),

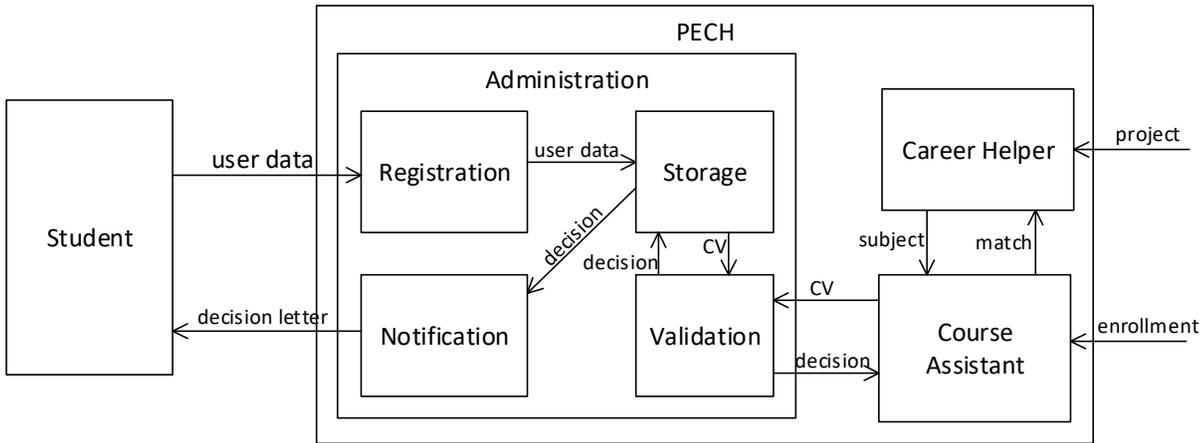
- A. One can argue that an architecture is actually a structure of structures needed to reason about the system. Explain why (5p).
- B. Not having an inconsistent architecture documentation is a key task of the architect. Inter-views, defining the relations between the different architectural elements in different views assists in this. Explain whether these inter-views are a viewpoint or a perspective on the architecture (5p).

In essence, software realization can be seen as creating a mapping from the architectural artifacts to the realized software units.

- C. Explain whether this mapping is an architectural view, and/or part of the realized software units (5p).
- D. Explain why Architecture Compliance Checking and Architecture Reconstruction can be seen as two sides of the same coin (5p).
- E. Explain the relations between a model, a view and a structure (5p).

## II. Views and their consistency (25 points)

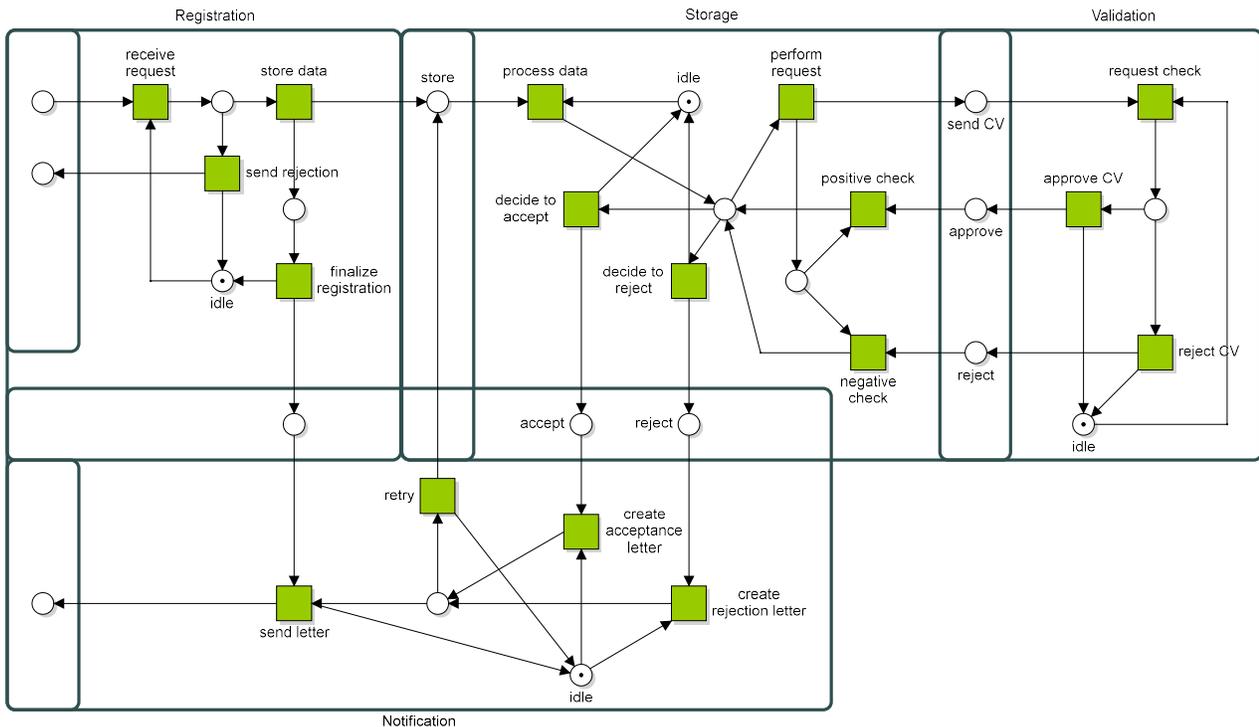
The Private Education and Career Helper (PECH) is a system that helps students in finding the best courses and career prospects. One of the views is the Functional Architecture Model as depicted below.



As shown in the FAM, the Administration module consists of four main submodules: Registration, Validation, Storage and Notification. After Registration, the data is sent to the Storage submodule. In 10% of the cases, the Storage submodule passes the user data to the Validation module. In all other cases, the Notification submodule sends a message to the user. Unfortunately, in 1 out of the 5 times, Notification fails. In that case, the user data is passed back into the Storage submodule. In total 70% of the output of the Validation submodule is fed back into the Storage submodule.

- A. Draw a scenario that best describes the above scenario as an overlay on the FAM given on the answer sheet (5p).

One of the architects want to analyze the protocols between the submodules of the Administration module, and delivers the following Petri net.



- B. Explain to which viewpoint this Petri net belongs (5p).
- C. An important property of architecture documentation is consistency. Are (1) the Petri net, (2) the scenario, and (3) the FAM consistent with each other? Explain your answer (2+8p).

An important notion in modelling is correctness: the model should be correct, and it should be the correct model. For Petri nets, weak termination and proper completion are two important concepts that together form the correctness notion considered in the lectures.

- D. Is the above Petri net correct? Explain your answer (5p).

### III. Quality properties and their analysis (30 points)

An architect not only considers functional requirements, but also quality properties.

- A. Explain how the viewpoint catalogue can assist the architect in analyzing a quality property (5p).
- B. One way to address a quality property is through quality scenarios. Such a quality scenario can be seen as an architectural view. Explain to which viewpoint this view belongs best. (5p).

Consider PECH as introduced in Question II. The Administration module is critical for the performance of this system. Therefore, architect decides to do an additional analysis. As shown in the FAM, the Administration module has two incoming sources: one into Registration, and one into Validation. The former receives 4 requests per minute, the latter receives 5 requests per minute. Registration is expected to take 10 seconds to handle a single request. The Storage submodule has a service time of 15 requests per minute. The Notification and Validation submodules both handle 10 requests per minute.

- C. Draw the queueing network (“Jackson”) that describes the above system (5p).
- D. Calculate the output rate of the Validation submodule to the Course Assistant module, following the FAM in Question II and the queueing network drawn above for question III.C (10p).
- E. Calculate the expected total time items spent in the Administration module (5p).

#### M/M/1 formulae

- Utilisation:  $\frac{\lambda}{\mu}$
- Expected number of elements in a node:  $\frac{\rho}{1-\rho}$
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#### IV. Architectural styles and product lines (20 points)

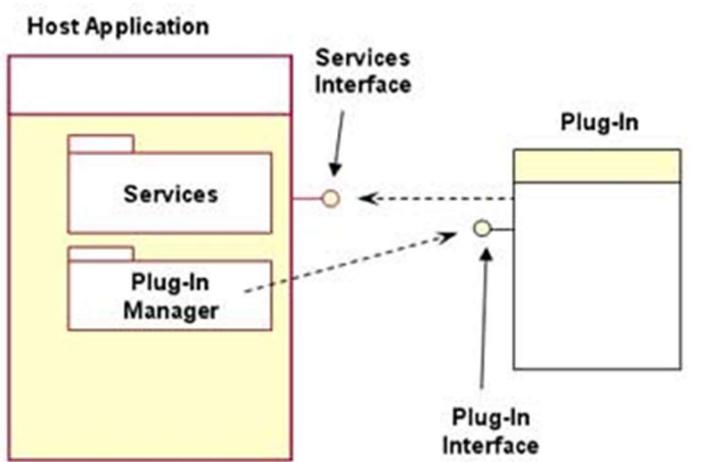
Given is the definition of a Product Line: A product line of software is a set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way.

A. Explain the difference between a variability point and a variation mechanism (5p).

Consider PECH again. Notifications are delivered by sending physical letters. PECH now wants to support multiple ways of sending the notification, including email.

B. Explain how quality scenarios can be used to define a variability point for the above situation at PECH, **and** give an example of such quality scenario for PECH (3+2p).

Given is the following figure.



C. Explain how plug-ins realize a variation mechanism in a product line (5p).

Given is an excerpt of the table on variation mechanisms, with three variation mechanisms described.

| Variation Mechanism         |  | Properties building the Core Asset |                            | Building the Product Variant |          |        |
|-----------------------------|--|------------------------------------|----------------------------|------------------------------|----------|--------|
| Name                        | Definition   | Cost                               | Skills                     | Stakeholder                  | Tools    | Cost   |
| <b>Runtime conditionals</b> | Selective execution of control flow  | Medium                             | No special skills required | Product developer            | None     | None   |
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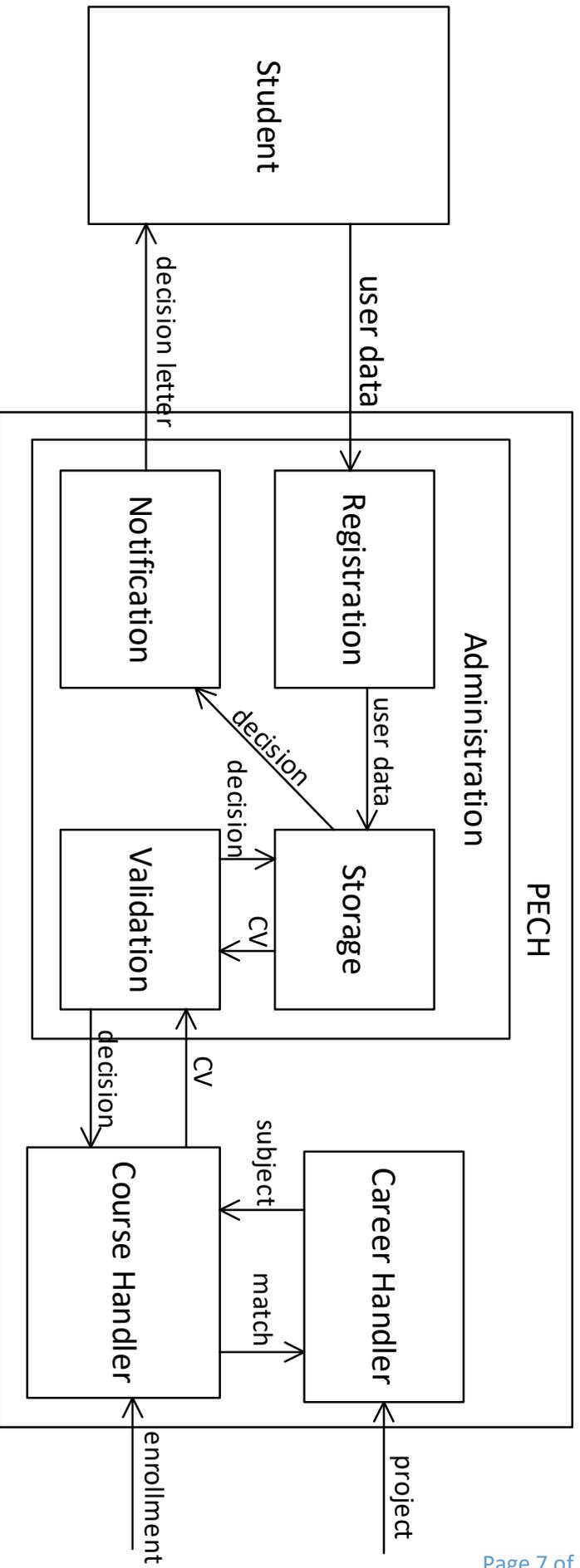
D. Explain why Cost and Skills are important for “Properties building the Core Asset” (5p).

▪ End of exam

Answer for question II.A

Name: \_\_\_\_\_

Student ID: \_\_\_\_\_



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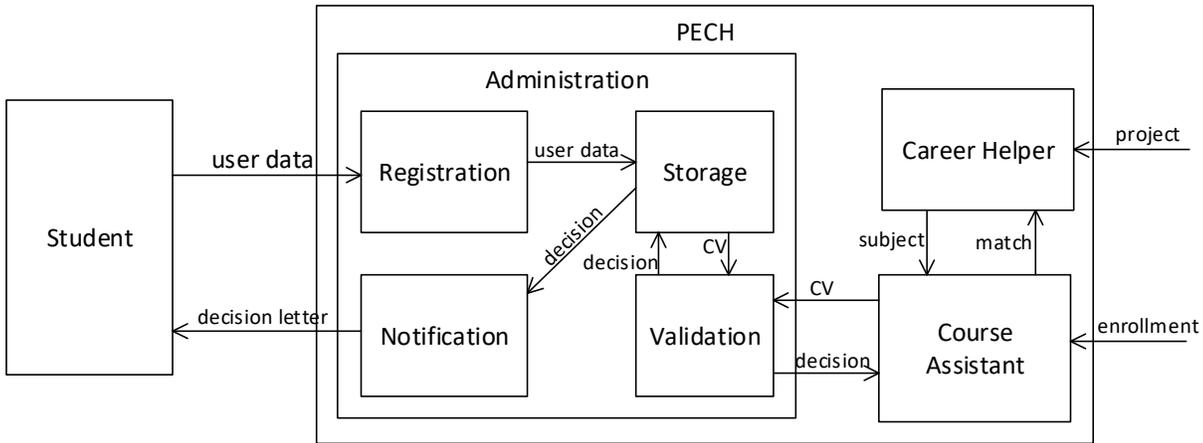
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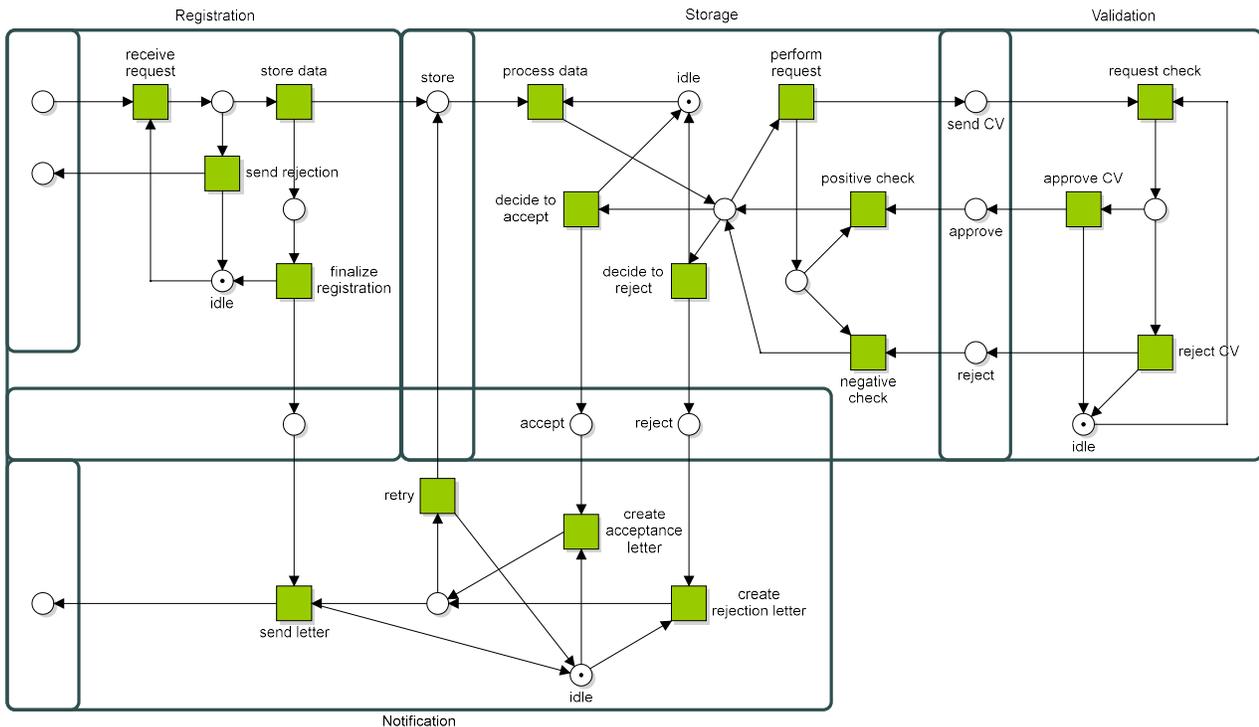
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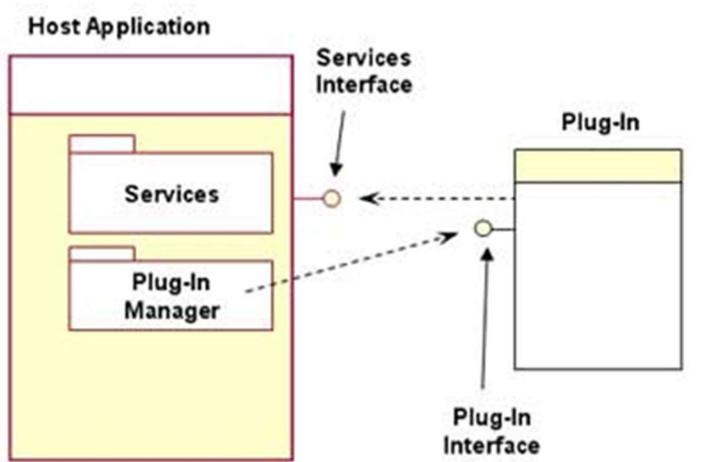
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