1 (a) (i) The car width, parking tolerance and exit tolerance all vary independently, and it can be calculated that 32.5% of the customers will be unable to exit their cars comfortably. Details are given below.

[20%]

		original			
		mean	min	max	dev
single space	w_1	3.2			
car width	w	1.85	1.75	1.95	0.10
exit tolerance	b	0.8	0.7	0.9	0.10
parking tolerance	a	0.4	0.1	0.7	0.30
m		0.15			0.33
z		-0.4523			
P(z)		0.6745			
1 - P(z)		32.55%			

(ii) The minimum single bay width which would allow at least 95% of the customers to exit their cars comfortably is 3.6m, calculated by setting P(z) = 0.95 and solving for m. Details are given below.

[20%]

		modified			
		mean	min	max	dev
single space	w_1	3.60			
car width	w	1.85	1.75	1.95	0.10
exit tolerance	b	0.8	0.7	0.9	0.10
parking tolerance	a	0.4	0.1	0.7	0.30
m		0.55			0.33
z		-1.6459			
P(z)		0.95			
1 - P(z)		5.0%			

(b) (i) The total space now under consideration is the new left hand space created with a width of 3.2m plus the 0.4m on the left side of the car in the right hand car park. This is compared to the car width and space either side, with 11% of cars not able to fit in the space and allow the driver to exit comfortably. Details are given in the table below.

[20%]

		original			
		mean	min	max	dev
RH space	w_1	3.6			
car width	w	1.85	1.75	1.95	0.10
exit tolerance	b	0.8	0.7	0.9	0.10
parking tolerance	a	0.4	0.1	0.7	0.30
LH space	w_2	3.2			
car width	w	1.85	1.75	1.95	0.10
exit tolerance	b	0.8	0.7	0.9	0.10
parking tolerance	a	0.4	0.1	0.7	0.30
m		0.55			0.45
z		-1.2298			
P(z)		0.8906			
1 - P(z)		10.94%			

(ii) Similar calculation in (a) part (i), but requiring the extra 0.4m space for the right-hand parked car, giving a minimum space of 3.4m for the left hand parking space to allow 95% of drivers to exit comfortably.

[20%]

		modified			
		mean	min	max	dev
RH space	w_1	3.6			
car width	w	1.85	1.75	1.95	0.10
exit tolerance	b	0.8	0.7	0.9	0.10
parking tolerance	a	0.4	0.1	0.7	0.30
LH space	w_2	3.4			
car width	w	1.85	1.75	1.95	0.10
exit tolerance	b	0.8	0.7	0.9	0.10
parking tolerance	a	0.4	0.1	0.7	0.30
m		0.74			0.45
z		-1.6460			
P(z)		0.95			
1 - P(z)		5.0%			

(c) Extending the above design method to a multi-bay car park design, with marked spaces, implies that the far right-hand parking bay will need to be 3.6m wide and all other parking bays will need to be 3.2m wide, if 95% of customers to be able to exit comfortably.

Comments can also mention: this is a theoretical calculation; in practice people won't park filling up from the right; the problem has been simplified to maintain the independence; the co-dependence of variables; some drivers may not park parallel to the sides of the parking bay; some drivers may reverse into the park meaning the exit tolerance swaps sides; the distribution of the independent variables may not be normal in practice; parks for disabled users or parents with children need to be wider; the design does not consider how difficult it may be to turn into the car park; drivers may arrive at different times and stay for varied lengths of time at the store, etc.

[20%]

Comments

This was a popular question looking at the probabilistic interference between cars parking. Most candidates could find the means and standard deviations, and frame the problem correctly. A few managed to miss out one of the variables. Candidates could either calculate the interference between 2 cars almost perfectly, or not at all. Many candidates could apply their results to multi-bay car park design, but few commented on the limitation of their model in real life situations.

2 (a) The statement could be of the form: Devise a means to enable users with severe hand tremor to unlock a device while simultaneously preventing unauthorized access.

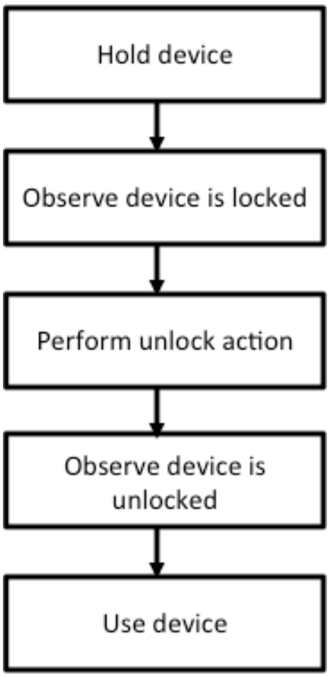
[10%]

(b) Key requirements for the new locking feature should include reference to some or all of the following:

- The locking feature should prevent unauthorized users from access the device.
- The locking feature should enable as many authorized users as possible to unlock the device.
- The locking feature should allow authorized users with severe hand tremor to unlock the device.
- The locking feature mechanism should be easy for users to understand.
- The locking feature should allow users to quickly unlock the phone.

[20%]

(c) The process function structure should be relatively simple, but should make reference to observing the lock state and the lock action.



[20%]

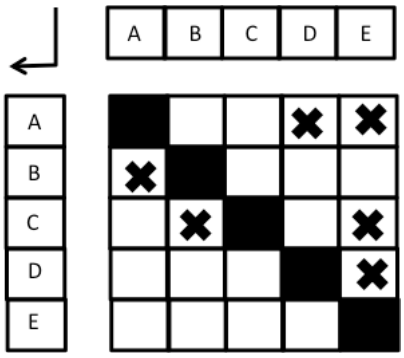
(d) There are a number of possibilities here, accepting that this is a difficult problem to solve well. Marks given for solutions that clearly meet the requirements and are communicated well. The majority of marks to be gained for solutions that prevents unauthorized access and at the same time maximise the probability that an authorized user with severe hand tremor can access the device. Solutions are likely to either attempt to mitigate the impact of hand tremor directly, for example by using a low-pass filter or providing additional hard keys, or use a different authorization mechanism, such as a unique gestural pattern or a display with fewer but larger PIN keys on the screen. There are no obvious winning solutions here and credit will be given to those who demonstrate a real understanding of the challenge in their solution.

[50%]

Comments

Another popular question with candidates. Candidates were generally able to provide an acceptable solution-neutral statement and a reasonable set of requirements. Many candidates struggled with the latter conceptual part of the question and presented naïve concepts with little emphasis on solution principles and trade-offs. Many solutions also suffered from fixated thinking. Overall, candidates provided acceptable answers to the different parts of the question but most answers were unexceptional.

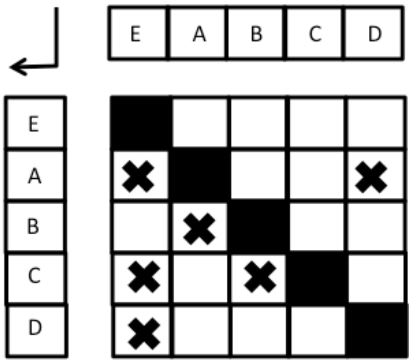
3 (a)



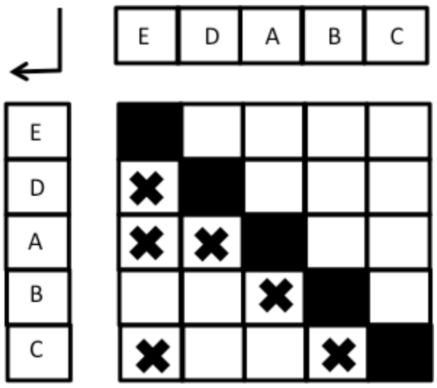
[20%]

(b) All feedback marks are eliminated when the DSM is in lower triangular form. This is achieved by partitioning the DSM.

Task E does not depend on anything, move to first position.



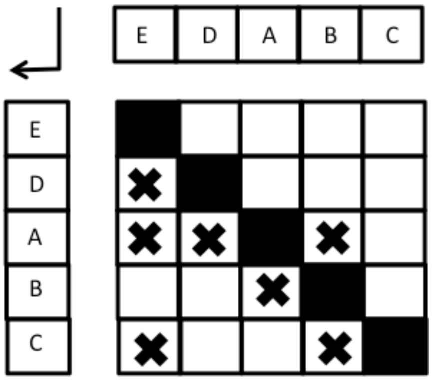
D only depends on E, move to second position.



The DSM is now in lower triangular form.

[30%]

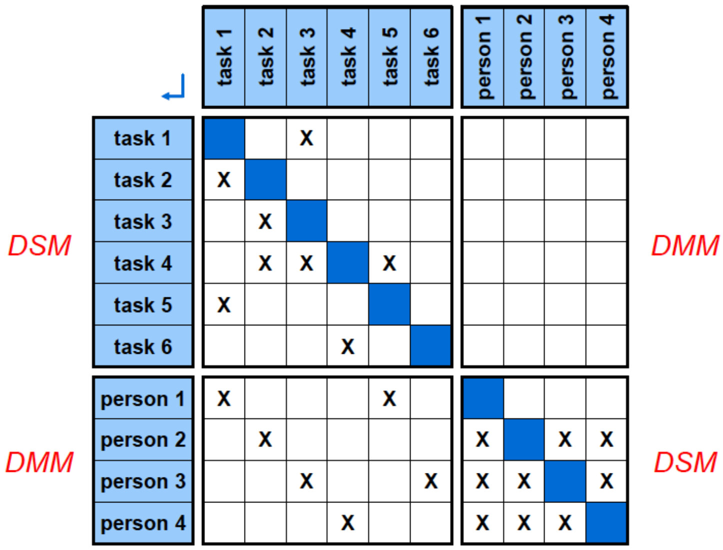
(c) The DSM is now:



There are two strategies. First, A and B could be executed concurrently (integration strategy). Second, B could be deconstructed into B1 and B2, where only B2 depends on A. Reorder A, B1 and B2 to make the DSM lower triangular (decomposition strategy).

[30%]

(d) A multiple domain matrix (MDM) models a system consisting of two domains. The MDM consists of two DSMs and two Domain Mapping Matrices (DMMs). The DSMs model a single domain as usual and the DMMs model the interactions between the domains. There are many potential system structures that can be analysed with MDMs, a very typical example is a system consisting of tasks and people. An example figure may be included in the answer but is not required.



[20%]

Comments

This was a new type of question, this year, and only a minority of the students attempted this question. Most candidates could draw the correct dependency structure matrix and partition it to remove feedback marks. Some candidates accidentally transposed the matrix, which still results in an acceptable answer, but then failed to realise that in order to remove the feedback marks the matrix now needs to be in upper triangular form. A few candidates struggled to apply integration and decomposition strategies to solve the latter part of the question. Some candidates found it difficult to explain the multiple domain matrix. Overall the candidates who attempted this question did fairly well and a few candidates did very well.

4 (a) Key elements of good risk management might include:

1. careful assessment of the requirements for the new voting system;
2. careful planning and design of the change in system;
3. piloting of the proposed new voting system to provide evidence of its security and effectiveness;
4. clear definition of the system performance metrics and associated monitoring methods;
5. risk analysis of the new system and transition arrangements;
6. comparison between the effectiveness of the new electronic voting system and the traditional voting system
7. communication of the system changes to voters, election officials, media

[40%]

(b) Key requirements might include:

(i) simple and easy to use interface for voters

(ii) centralised computer system to collate votes

(iii) secure method to transfer of vote over the internet

(iv) feedback to voter that their rote has been register

(v) method to identify voter, and check them against a voter registry

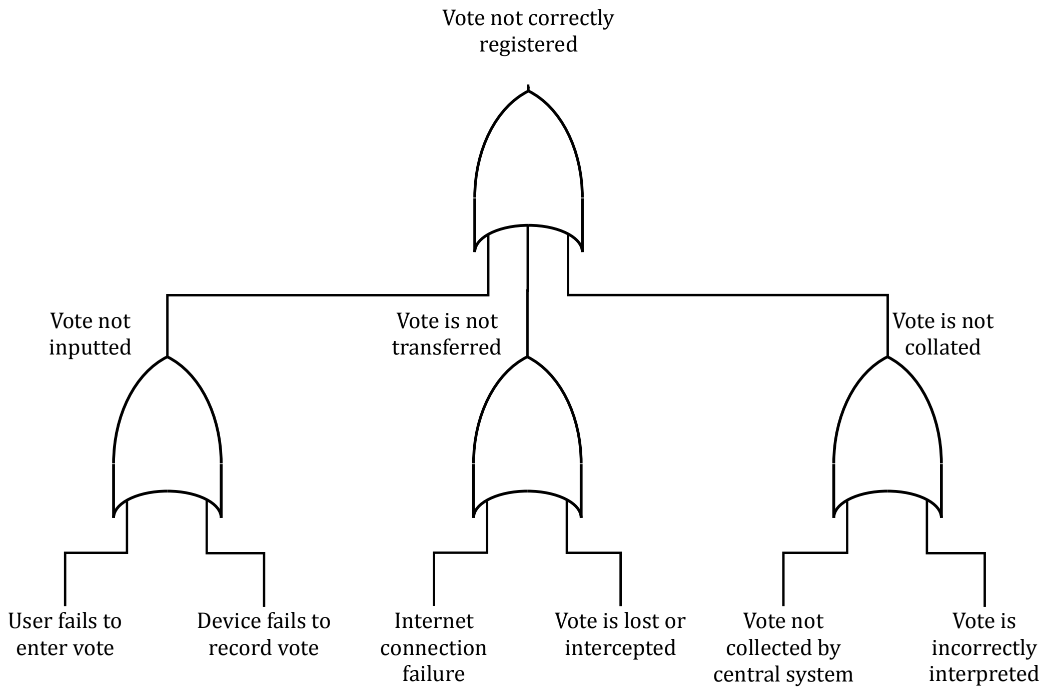
(vi) check to allow voters to only register one vote

(vii) ability to count votes, and provide updates to the media

(viii) security over all parts of the system (i.e. encryption)

[20%]

(c) All 'gates' in the tree are likely to be OR gates. Fault tree can take a number of different forms, but should address issues across the entire system.



[20%]

(d) From the notes, the key issue is that the system must be proven to be "fit for purpose. The system should be validated (checked against the user need) and verified (checked against the specification) throughout the design and implementation process.

(i) a detailed list of the system requirements should be validated with the UK Government, voting officials, voters and media to ensure it leads to a system which is "fit for purpose"

(ii) high risk parts of the system should be identified and tested early in the design process

(iii) early involvement of a cross-section of voters would help in the design of a simple and easy to use interface

(iv) formal verification through trials of each part of the system to ensure reliability, security and quality of function are delivered

(v) formal verification through trials of the new voting system, as a whole, to ensure effective and accurate operation, and that security is not compromised

(vi) review of the results of the formal trial in the Cambridge constituency, from the technical and the stakeholders satisfaction angle.

[20%]

Comments

This was the most popular question. Almost all candidates we able to describe risk management practices from the lecture notes, with some having better recall and structuring of their answers than others. Disappointing was the lack of context provided by the candidates, with most failing to relate the concepts to the specific problem of designing an on-line voting system. Candidates could have written more for part (a) worth 40% of the marks, and the fault trees could have been more comprehensive.