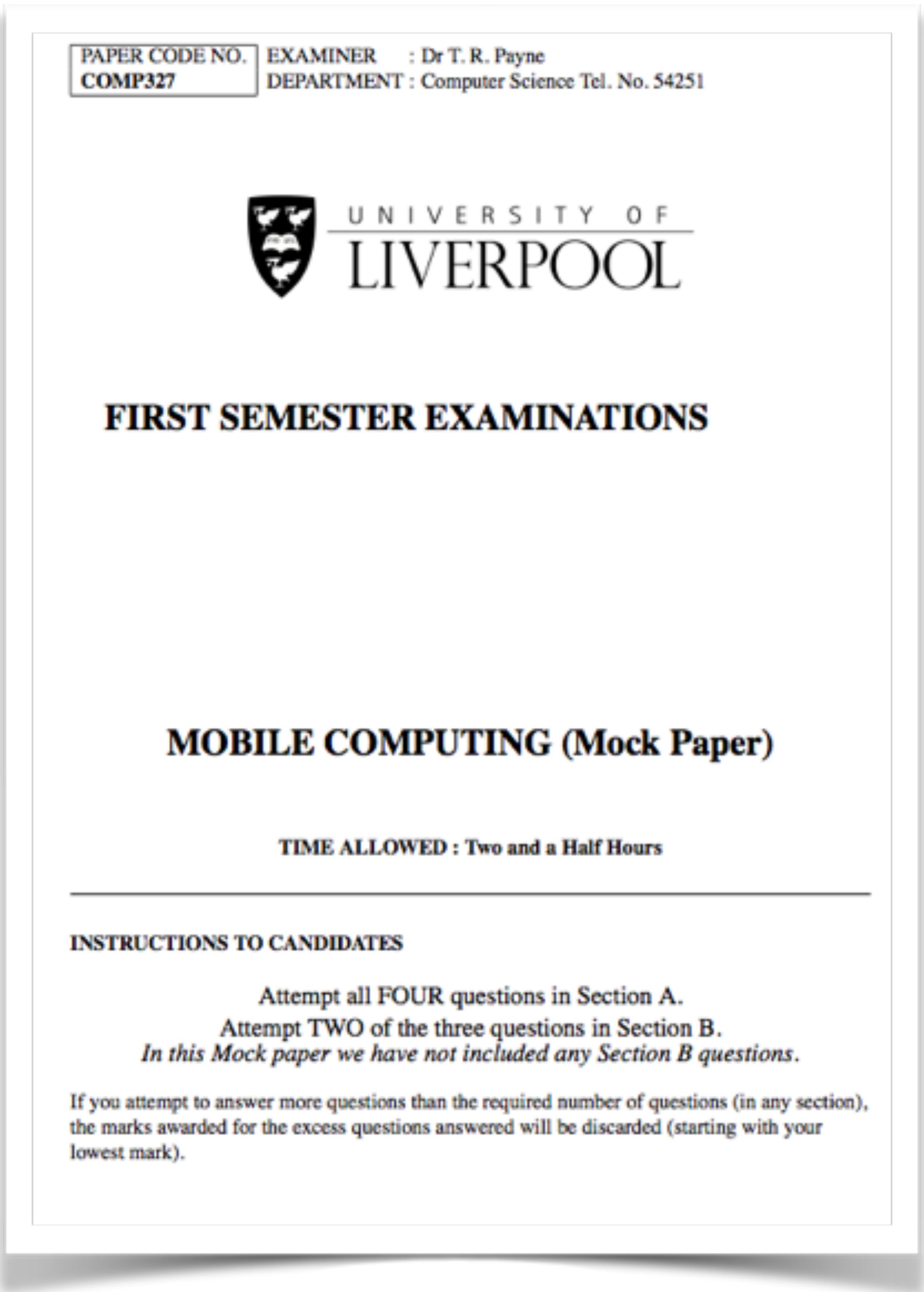
COMP327
Mobile Computing

Mock Exam Paper (Revision)

Exam Paper and Rubric



PAPER CODE NO. COMP327	EXAMINER : Dr T. R. Payne DEPARTMENT : Computer Science Tel. No. 54251

UNIVERSITY OF LIVERPOOL

FIRST SEMESTER EXAMINATIONS

MOBILE COMPUTING (Mock Paper)

TIME ALLOWED : Two and a Half Hours

INSTRUCTIONS TO CANDIDATES

Attempt all FOUR questions in Section A.
Attempt TWO of the three questions in Section B.
In this Mock paper we have not included any Section B questions.

If you attempt to answer more questions than the required number of questions (in any section), the marks awarded for the excess questions answered will be discarded (starting with your lowest mark).

- The exam paper format has changed from previous years:
  - Section A
    - Complete all four questions, each worth 10 marks
      - Reduced from 5 questions
  - Section B
    - Complete two of three questions, each worth 30 marks
      - Questions are now worth 5 marks more
- Exam is 2 $^1/_2$ hours long

Coverage

- Any of the material taught could appear in the exam
- Questions may be
  - Book work (what can you tell me about ...)
  - Discursive (contrast this and that and discuss the pros and cons)
  - Problem solving (given this, what is that)
- Past Papers and Mock Papers are available
  - See Course Web Site

Mock Questions

- **Question 1**
  - The use of some wireless radio communication technologies can be used to disseminate content to user's devices. Whilst this may be desirable in some scenarios, it may also be unsolicited, or potentially malicious in others. Explain how Bluetooth could be used to disseminate such content, and discuss the ethical issues, with examples of scenarios where this may be either desirable or malicious ? (5 marks)

Bluetooth

- An open wireless protocol for exchanging data
  - Short range (1-100m) depending on class and power
  - Frequency hopping spread spectrum
    - Data is chopped up and transmitted as chunks over 79 separate frequencies.
- Designed as a "cable replacement" technology
  - Establishes piconet, with one master and up to 7 slaves
  - Scatternets form when two or more piconets share members

Bluetooth

- Dynamic discovery and connection mechanism
  - Security mechanisms employed through pairing
    - Uses the Service Discovery Profile (SDP)
    - Devices can be in discoverable mode
      - Transmits name, class, list of services and technical information
    - Paring is then performed using a link key (i.e. a shared code)
      - If stored by both devices, then they are bonded
    - Once pared, devices in range can be recognised and dynamically connected
  - Various security vulnerabilities have been identified
    - Bluejacking involves sending unsolicited messages to a device
    - Bluecasting is a variant, used for proximity marketing
      - e.g. Hypertag Ltd

Hypertag®

Excellent Solution (10/10)

The use of some wireless radio communication technologies can be used to disseminate content to user's devices. Whilst this may be desirable in some scenarios, it may also be unsolicited, or potentially malicious in others. Explain how Bluetooth could be used to disseminate such content, and discuss the ethical issues, with examples of scenarios where this may be either desirable or malicious ? (5 marks)

Bluetooth is often used to facilitate both Bluejacking and Bluecasting.

Bluecasting is a means of sending small digital media to suitable media-enabled devices over Bluetooth via the OBEX protocol. Small digital media does not exclusively mean advertisements but could include photos, podcast style audio content, video, mobile ticketing, text messages, games (especially those written in Java ME) or even other applications. A bluecast is generally provisioned by a Bluetooth Kiosk a physical server provisioning the digital media over Bluetooth to interested devices. Bluetooth Kiosks are generally located in public spaces such as malls, bars or mass-transit terminals. In India there are some temples which offer ringtones, wallpapers of gods and some other content using bluecasting. Bluecasting is also used by many companies to advertise about various offers by them.

In contrast, Bluejacking is the sending of unsolicited messages over Bluetooth to Bluetooth-enabled devices such as mobile phones, PDAs or laptop computers, sending a vCard which typically contains a message in the name field (i.e., for bluedating or bluechat) to another bluetooth enabled device via the OBEX protocol. Bluejacking is usually harmless, but because bluejacked people generally don't know what has happened, they may think that their phone is malfunctioning. Usually, a bluejacker will only send a text message, but with modern phones it's possible to send images or sounds as well. Bluejacking has been used in guerrilla marketing campaigns to promote games.

Poor Solution (3/10)

The use of some wireless radio communication technologies can be used to disseminate content to user's devices. Whilst this may be desirable in some scenarios, it may also be unsolicited, or potentially malicious in others. Explain how Bluetooth could be used to disseminate such content, and discuss the ethical issues, with examples of scenarios where this may be either desirable or malicious ? (5 marks)

Messages can be sent using Bluetooth to peoples phones to tell them about things, such as sales offers. People might not want to hear about these things, and it could hack them off!

Correct, but short. Doesn't discuss the pros or cons - thus 3/10

Bluetooth can be used to hack peoples phones and leave malicious files or delete information.

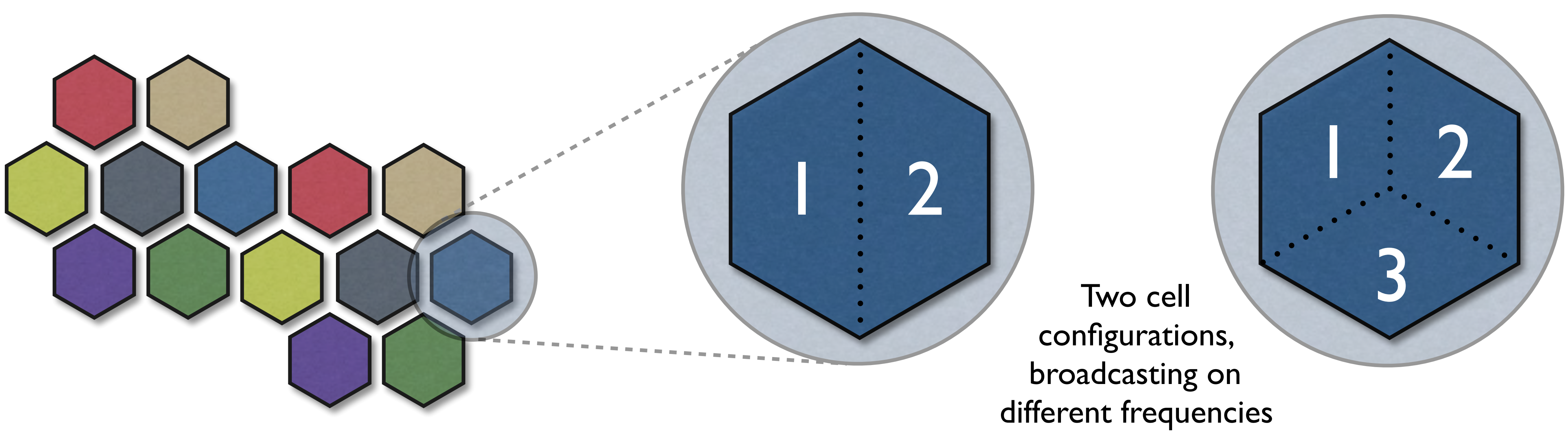
Simply Wrong!

Mock Questions

- **Question 2**
  - Assume a GSM Base Transceiver Station cell is split into 3 sectors, with each sector covered with 2 transmitter/receiver pairs. Also assume that each transmitter/receiver pair uses 1 time slot for signalling, and an additional time slot for GPRS data. Given a theoretical call profile model of 2 minutes per hour, what would be the subscriber provision for that cell? (5 marks)
  - If the demand for data increases the number of time slots needed for GPRS data from 1 to 3 time slots per transmitter/receiver pair, how many additional transmitter/receiver pairs will be needed per sector to maintain the same subscriber provision for that cell? (5 marks)

GSM BTS Cells

- A form of space division multiplexing is used to avoid interference
  - Each cell typically only operates on a limited number of frequencies, to avoid interference with its neighbours
  - To increase capacity, the coverage area is usually split into two or three sectors, covered using different frequencies by a dedicated transmitter
    - Improves reuse of frequencies in 2D space, compared to a single frequency per cell.



Cell Capacity

- It is possible to calculate the cell capacity, and hence estimate subscriber provision
- Example scenario
    - Assume a BTS cell is split into 3 sectors, with each sector covered by 2 transmitters and 2 receivers.
    - Also assume that each transmitter/receiver pair uses 1 time slot for signalling, and 2 time slots for GPRS data
- Each GSM channel consists of 8 time slots, with uplink data going to the receiver, and downlink data coming from the transmitter
    - Therefore each transmitter/receiver pair has 5 time slots for voice calls
    - Given that there are two transmitter/receiver pairs in each sector, with three sectors in the cell, **the cell capacity is (5x2x3 =) 30 simultaneous subscribers.**
- Not all subscribers communicate at the same time.
    - Mobile providers use a "*theoretical call profile model*" to determine the number of minutes on average a subscriber uses per hour.
    - If this profile states that for an hour, the average use is 1 min, then a cell can support 60 times the number of active subscribers.
    - **Hence, the subscriber provision per cell is (30x60 =) 1800 subscribers.**

Case Study

Vodafone Germany had a subscriber base of aprox 25 million in 2005. By dividing this number by the subscriber provision per cell, the number of BTSs needed can be calculated.

Given the figures opposite, this would be aprox 14,000, which is in line with the number of actual BTs used by Vodafone Germany!!!

Excellent Solution (10/10)

Part a)

A GSM frame consists of 8 time slots that can be used for signalling, voice circuits and GPRS data packets. Therefore, each transmitter/receiver pair can support six time slots for voice calls. Given that there are two transmitter/receiver pairs in each sector, with three sectors in the cell, the cell capacity is v x s x t, where v is the number of voice time slots, s is the number of sectors, and t is the number of transceivers (i.e. transmitter/receiver pairs).

This gives: 6 x 3 x 2 = 36 simultaneous subscribers.

The theoretical call profile model determines the actual subscriber provision, given the number of possible simultaneous subscribers. As this profile assumes (on average) 2 minutes of use per subscriber per hour (i.e. a provision of 30 subscribers per hour), the subscriber provision per cell would be 30 x 36 = 1080 subscribers.

Part b)

If the data demand increases from one time slot to three, this will reduce the number of time slots available for calls from 6 to 4 time slots. To maintain the same provision per cell (given that the theoretical call profile model doesn't change), the number of transmitter/receiver pairs would have to increase to maintain a capacity of 36 simultaneous subscribers.

Thus, we have to calculate 4 x 3 x t = 36, where t is the number of transceivers required to maintain a capacity of 36 simultaneous subscribers. Therefore, t=3, resulting in the need of one additional transmitter/receiver pair necessary per sector.

Poor Solution (5/10)

Part a)

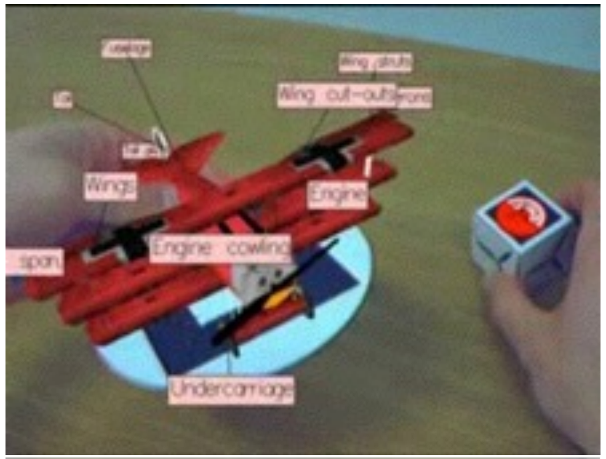
6 time slots for each transmitter/receiver pair
6 transmitter pairs in a cell
36 simultaneous calls
30 calls per hour
1080 subscribers

Part b)
Maintain 36 simultaneous calls
Now only 4 time slots for each transmitter/receiver pair
Three sectors, so 12 calls per sector
Need 3 transmitter/receiver pairs

- Why is this not so good?
  - The facts have been stated but not explained. Why are they relevant?
  - How do I know if you have understood the what is going on?

Mock Questions

- **Question 3**
  - Discuss three of the primary technological challenges that are faced in developing location-based Augmented Reality applications. Discuss the potential hazards of using such applications on a mobile device, when compared to using such systems within an indoor laboratory environment. (10 marks)

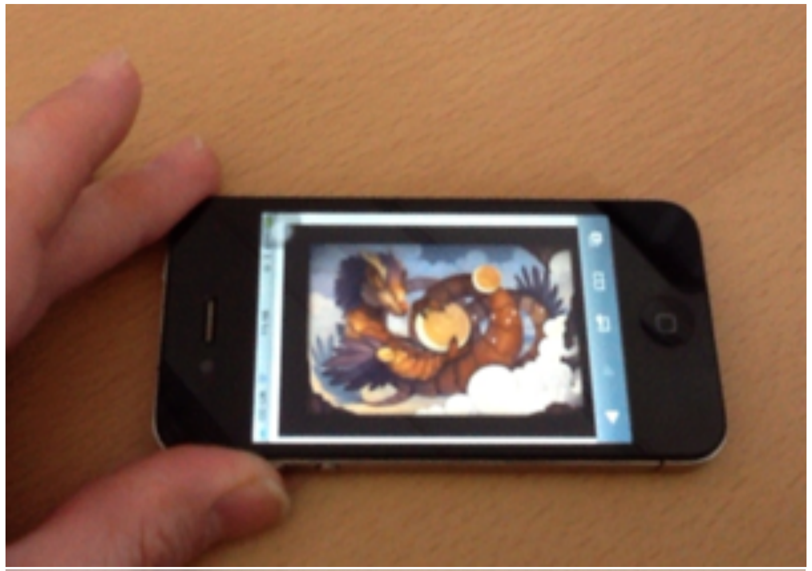


Augmented Reality

- Combining live direct (or indirect) view of a physical real-world environment with virtual CGI
  - Typically in real-time using the semantics of environmental elements
  - Identify digital "cues" (e.g. 2D barcode) and overlay with a digital image
    - Video camera identifies orientation of the cue, and replaces it with the image, transforming it in 3 dimensions
- Can be used to enhance the environment
  - Provide details about the environment, by "projecting" labels or directions onto the street or building being viewed
- Can be used for entertainment
  - Project games into the real-world, by identifying cues to determine location or features

Augmented Reality

- To develop augmented reality applications, several technological challenges need to be overcome:
  - Live video is required to project the graphics onto
    - i.e. the app needs to display in real time what the user is looking at, and add the "augmented images" onto that video
  - Positioning information required, to determine relative location of other artefacts that may be annotated
    - Applications that annotate locations or give directions (e.g. Yelp) first need to determine the user's location (using GPS or other location mechanism), device orientation (using accelerometer) and compass direction (using magnetometer) to determine **what** the user is looking at
    - Then the objects that are being looked at need to be presented over the video feed, in the correct position (e.g. building annotations or directions)
  - Image analysis is required to identify cues to overlay graphics
    - Applications such as Word Lens identify text, and replace this with other text corresponding to a translation (e.g. English-Spanish)
    - Other Apps identify patterns (and their orientation) to determine what should be displayed, and in what orientation it should be displayed



Augmented Reality

- Using Augmented Reality apps in real world (on the go) scenarios can be hazardous!
  - Conventional apps require some attention from reality/environment
    - Users on the go might focus some time on the app, but will also retain awareness of their environment
  - Augmented reality apps provide some awareness of reality/environment
    - Users can be lured into relying on the app to provide that awareness of their environment
- However, this can restrict full awareness, or become fixated on details, and thus act in a dangerous, or unexpected way
  - e.g. loss of peripheral vision etc

Excellent Solution (10/10)

Location-based augmented reality applications are those applications that determine what should appear on the screen, based on the user's location, the user's orientation (I.e. in what compass direction the user is facing, or holding the device) and the orientation of the device itself (the angle of the device with respect to the horizon, to determine whether the user is facing the ground or looking into the sky). This contrasts with augmented applications that are subject-based, whereby the augmentation is determined by recognising and analysing objects in the video feed.

To develop location-based augmented reality apps, there are several challenges that need to be addressed: three of which include 1) determining what the user is looking at; 2) determining the relative position of other locations which will determine the augmentations on the screen; and 3) overlaying the augmentations on the screen in real time, such that they respond realistically when the device is moved around.

Challenge 1: the device needs to determine the user's location as accurately as possible (ideally using GPS) and their orientation (with respect to magnetic or true north) to determine what the user is looking at. Accuracy is important, especially when the objects being viewed are very close.

Challenge 2: once the users position is known, the relative position of nearby objects can be calculated, in terms of orientation with respect to the user. This means that objects to the north of the user should only produce annotations on the screen when the user is facing in that direction. Proximity may also be used to determine whether or not the annotations should appear (e.g. Only show locations that are nearby rather than far away, or show the closest station in this direction etc).

Challenge 3: a video feed should be obtained from the device's camera, and displayed on the screen. In addition, an annotation should be constructed and inserted into the video feed, in a location that represents the direction the object, without necessarily impairing the users ability to see what is in the environment - I.e. annotations should augment, not obscure the view.

One problem encountered, however, when using such applications is that they are typically relevant on the go (due to their "location"), rather than when used in a safe environment such as in a lab or office. This could be due to the application directing the user to a location, or providing further information about the object the user is viewing (such as landmarks in a city). As such, there is a real danger that the user will loose full awareness of the environment, due to their focussing on the device, or reading the annotations, which could lead to accidents - such as bumping into objects not immediately visible on the screen (e.g. Bollards, or steps).

Poor Solution (4/10)

The challenges are:

1) determining what the user is looking at, and at what angle
2) determining where other things are, and their relative position
3) creating labels on the screen to point to where the other things are

Hazards could be due to walking into people or other things on the street

- Why is this not so good?
  - The answer simply states the facts, but doesn't explain them or justify them
    - why are these issues challenging?
    - why could the user walk into other people?

Mock Questions

- **Question 4**
    - How does Apple Pay on an iPhone differ from traditional contactless payment schemes used by credit and debit cards? (5 marks)
    - The Desktop and Mobile E-Commerce experience can differ wildly. Describe one limitation and one advantage of using a mobile device for e-commerce. (5 marks)

Mock Questions

- **Question 4**
  - How does Apple Pay on an iPhone differ from traditional contactless payment schemes used by credit and debit cards? (5 marks)
  - The Desktop and Mobile E-Commerce experience can differ wildly. Describe one limitation and one advantage of using a mobile device for e-commerce. (5 marks)

Contact-less Payment Systems

- Uses Near Field Communication (NFC) mechanisms such as RFID to communicate with receivers
  - Device is "passed" near to receiver, to perform transaction
    - May require some authentication using a PIN
  - Payment is then made via a pre-paid account, or billed directly
- Early adoption within mass-transit networks
  - Edy/Suica enabled phones used on Japanese Rail Network
  - Oyster Cards used on London Transport Network
- Embedded systems within devices
  - ApplePay and Google Wallet

Apple Pay

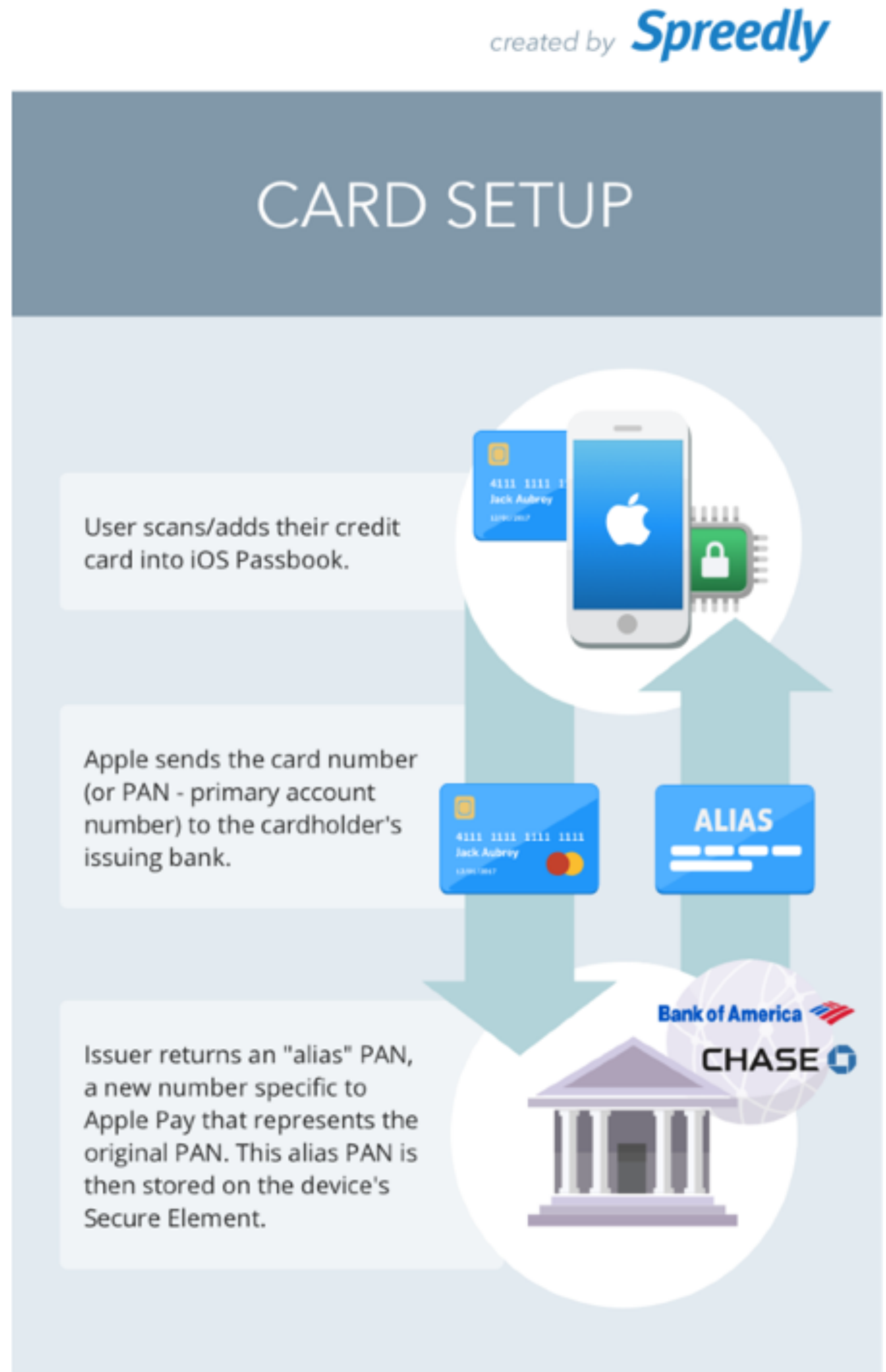
- An NFC-based payment system for the iPhone/iPad and Apple Watch
  - Uses NFC (tap and pay) for PoS purchases
    - Exploits the Contactless Payment System already in use by many Banks, etc
  - Biometric Authentication through TouchID used to initiate transactions.
  - A Secure Element (SE) hardware chip is used to store information relating to the user's bank cards

- Can support:
  - In-app payments directly to a bank account (as opposed to charging to an iTunes or Apple Store registered account)
  - Contactless PoS
  - Transport Networks (e.g. Transport for London)

- Advantages
  - Lower costs to Merchants (less opportunity for fraud)
  - Higher security for user (no credit card detail are revealed)

Apple Pay

- A User's credit/debit card is added to Passbook
    - The card details (PAN) are submitted to the Bank, that then returns a token representing the card
- The token is stored in a "Secure Element" in the user's device.



Excellent Solution (10/10)

How does Apple Pay on an iPhone differ from traditional contactless payment schemes used by credit and debit cards? (5 marks)

Apple Pay is Apple's mobile payments service, designed to allow iPhone users make payments for goods and services in retail stores using an NFC chip built into the phone. The phones contain an NFC controller where the ``Secure Element'' of Apple Pay is located, keeping customer information secure. To keep transactions secure, Apple uses a method known as ``tokenization,'' preventing actual credit card numbers from being sent over the air. When a credit or debit card is scanned into Passbook for use with Apple Pay, it is assigned a unique Device Account Number, or "token," which is stored in the phone rather than an actual card number.

A payment is made by holding an iPhone 6 or 6 Plus near a checkout system that includes NFC, most of which look like standard card checkout terminals within stores. A finger registered with Touch ID must be kept on the home button for a short amount of time, after which a payment is authenticated and the transaction is completed.

Credit and Debit cards also use the NFC mechanism to pass the card details (the number, expiry date and security code) to the reader. However, no further checks are typically required (athough occasionally the use might have to use chip and pin payment itself), and the vendor can always see the card details themselves, thus posing a possible additional security risk.

Mock Questions

- **Question 4**
  - How does Apple Pay on an iPhone differ from traditional contactless payment schemes used by credit and debit cards? (5 marks)
  - The Desktop and Mobile E-Commerce experience can differ wildly. Describe one limitation and one advantage of using a mobile device for e-commerce. (5 marks)

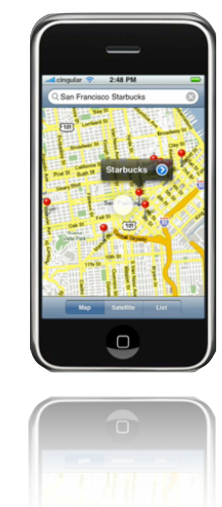
Mobile Commerce: evolving the E-Commerce Model

The Desktop Experience

- Large screen facilitates browsing of large catalogues
  - Requires significant user attention
- Goods can be organised conceptually and displayed graphically
- Significant real estate that can simultaneously support:
  - User context
  - Recommendations to related goods and user feedback
  - Advertising for related goods
  - Multi-column tabular data
- Easy user interaction
  - Facilitates payment through credit card, and providing user details
- Relatively Secure

The Mobile Experience

- Context aware
  - Knowledge of the user
  - Knowledge of the environment
  - Requires more autonomy due to restricted user attention
- Capable of interacting with local services and devices
  - Can scan physical goods
  - Can communicate with local services
- Always available and (more increasingly) always connected to the internet
- Existing service agreements through bearer network
  - Can support payment
- Unique identification through SIM and IMEI



Mobile Devices better suited to some tasks more than others

M-Commerce Scenarios

- Augmenting brick-and-mortar commerce
  - Use of RFID or NFC to detect goods
    - Can acquire additional information about the good
      - E.g. product information, price, reviews
      - Additional services such as preview (e.g. for music)
  - Using QR codes to identify, obtain or provide information
    - **Q**uick **R**esponse Code
      - Quicker than URLs; can be captured from billboards or printed media
      - Can encode numeric, alpha-numeric or kanji characters
    - Can display, as well as acquire visual codes
      - Airlines are increasingly using e-ticketing for boarding cards
      - Can use optical scanners to read barcodes from a mobile device
      - Deployments include Spanair, Air France, Lufthansa
- Advantages
  - Informed choice when purchasing goods

M-Commerce Scenarios

- Electronic Banking, Payment and e-ticketing
  - WAP Solo
    - Provides a means of payment to services via WAP for identified ticketing sites
    - Payments either from your bank account or via credit cards - including 3rd parties
  - iMode Felicia
    - Wireless payment scheme
      - Similar to use of Oyster card
      - Used for shopping, transportation, ticketing, membership card, etc
  - SMS payment and alerts
    - Warnings when bank limits are approached or new payments are instructed

- Advantages
  - Shorter queues with lower operating costs
  - Relax need for on-the-spot revenue collection technologies
    - e.g. coin-operated parking meters

Excellent Solution (5/5)

The Desktop and Mobile E-Commerce experience can differ wildly. Describe one limitation and one advantage of using a mobile device for e-commerce. (5 marks)

Two of the essential differences between the desktop and mobile E-commerce experiences are that of mobility and screen size. Desktop devices lack mobility, but enjoy the advantage of having large screens which can display a large amount of information graphically, whereas mobile devices lack that screen size, and therefore can only display a small amount of information. In contrast, Mobile devices can be taken into conventional "brick-and- mortar" stores, to assist in the purchasing of goods, whereas the desktop typically only supports commerce from a fixed location.

Given this, a limitation of using a mobile device for e-commerce is the lack of screen space for displaying much of the information typically presented to desktops through e-commerce sites. In many cases, products are not only listed, but can be organised graphically, or compared with other products. Information such as recommendations, related products or reviews can be displayed, as well as other links to browsing, search (via filters on price range, goods, or even manufacturers). Whilst this has greatly enhanced the shopping experience for online purchasers, the lack of screen size on mobile devices undermines the experience on a mobile device. If the user is browsing conventional web sites, the volume of data can often result in pages being rendered very small, requiring the user to zoom in and pan across the screen simply to understand what is being displayed. Some web sites provide mobile-specific web sites, engineered to better facilitate navigation and browsing; however, much of the associated information is often lost, or requires additional work for the user to view it.

In contrast, an advantage of using a mobile device is the ability to use it serendipitously when purchasing goods "on the go". By looking at physical products in shops, it may be possible to then look these up on price-comparison web sites to check out the cost of buying it elsewhere. Many apps now allow users to scan in the bar code, to assist looking up additional details of the product, or to build a virtual shopping list whilst perusing goods in the store, which can then be bought electronically and collected from the store (this is gaining traction with stores that maintain both an online and physical presence).

Excellent Solution (10/10)

How does Apple Pay on an iPhone differ from traditional contactless payment schemes used by credit and debit cards? (5 marks)

Apple Pay is Apple's mobile payments service, designed to allow iPhone users make payments for goods and services in retail stores using an NFC chip built into the phone. The phones contain an NFC controller where the ``Secure Element'' of Apple Pay is located, keeping customer information secure. To keep transactions secure, Apple uses a method known as ``tokenization,'' preventing actual credit card numbers from being sent over the air. When a credit or debit card is scanned into Passbook for use with Apple Pay, it is assigned a unique Device Account Number, or "token," which is stored in the phone rather than an actual card number.

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The Desktop and Mobile E-Commerce experience can differ wildly. Describe one limitation and one advantage of using a mobile device for e-commerce. (5 marks)

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