mobile business

Exercise 4

Technology Basics II

Mobile Business I (WS 2016/17)

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Literature

- This set of slides is based upon the following lectures:
  - ***Lecture 8:*** Smart cards and Related Application Infrastructures
  - ***Lecture 9:*** Mobile Devices
  - ***Lecture 10:*** Concepts of Mobile Operating Systems
  - ***Lecture 11:*** Market Overview of Mobile Operating Systems and Security Aspects

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Exercise 1: Smartcards

a) What are smart cards and what components do they consist of (=what do they contain)?

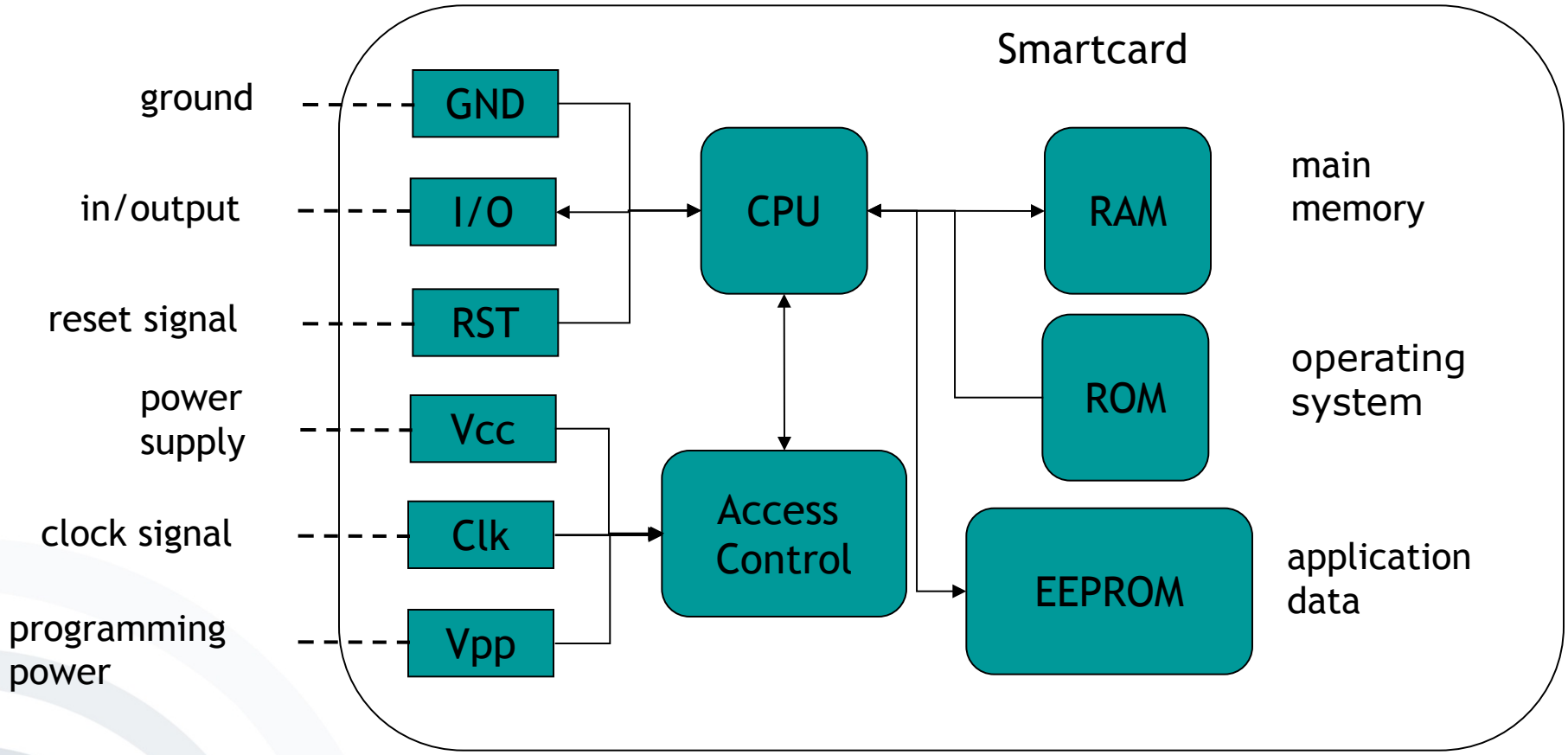
1

Smartcards

- Small computers with **memory**, **operating system**, **software**, **processor**, **I/O** and **access control**
- Chip **protected against manipulation**
- After being **initialised** with **keys** and other data smartcards are distributed to their users.

1a

Smartcards



1a

[Source: SecCommerce2002]

Exercise 1: Smartcards

b) Why are they used and what role do smartcards play with respect to
(i) security
(ii) applications?

1

Smartcards

- Used when **security** of data (e.g. for keys, signatures, physical access control, payment) is needed **in insecure environments**

- Examples:
  - Phone cards of Deutsche Telekom
  - Signature cards according to German Signature Law
  - Smartcard applications for PC
  - Smartcards for mobile communication (SIMs)

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Smartcards – Examples

1b

Why Smartcards?

Protection needed against:

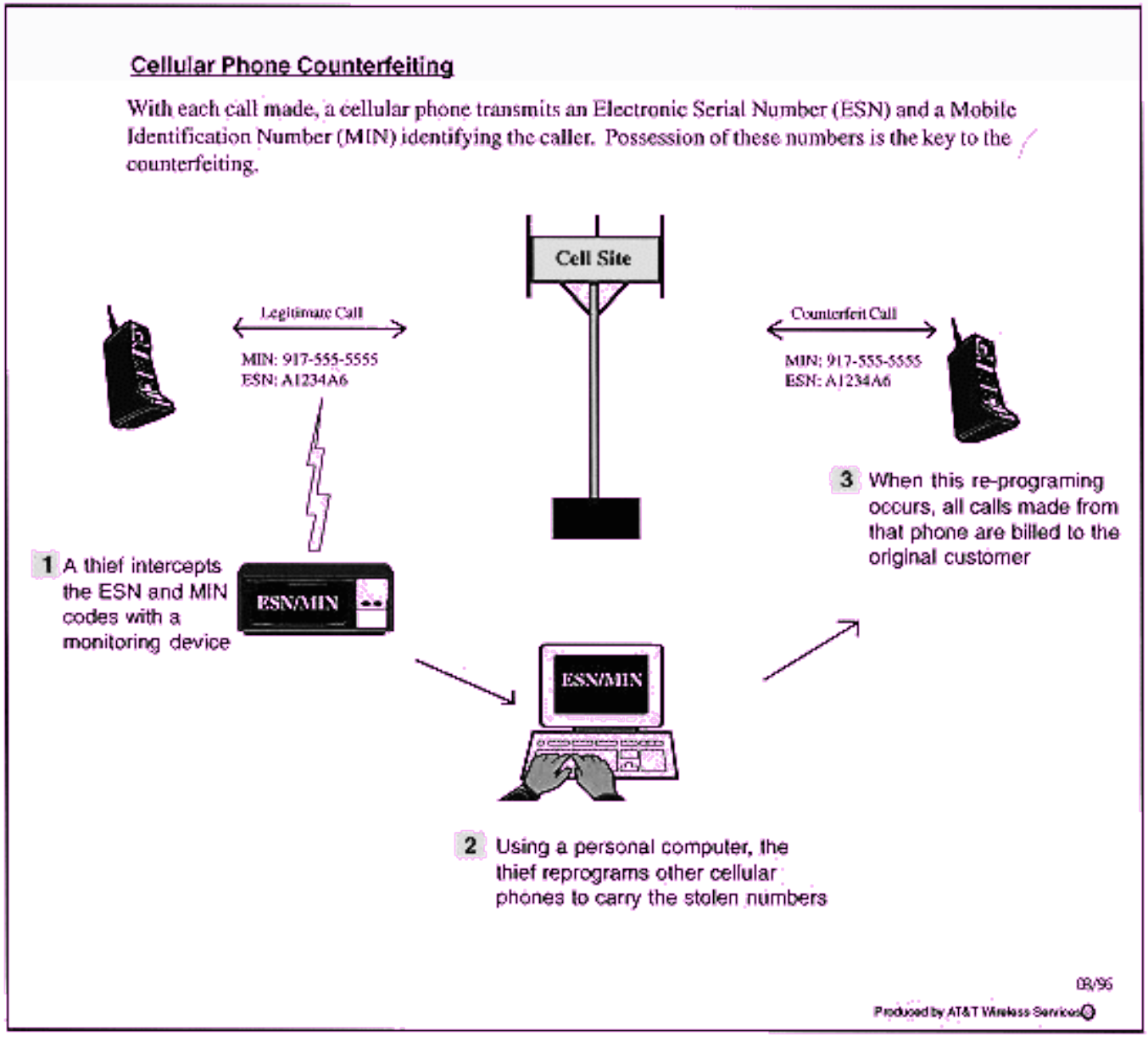
- Unauthorised usage of services through forged user data
- Duplication of a user's credentials
- „Cracking" of credentials
- Billing fraud

1b

CELLULAR COUNTERFEITING/CLONING FRAUD

Example for faulty system design (CDMA)

Duplication of intercepted user IDs



1b

Exercise 2: Subscriber Identity Module (SIM)

a) Name the most important function of the Subscriber Identity Module (SIM) in GSM and UMTS networks.

2

Smartcards for Mobile Communication

SIMs are **Smartcards:**

SIM cards serve as security medium.

Tamper-resistance prevents counterfeiting.

robust design

Contain **International Mobile Subscriber Identity (IMSI)** for subscriber identification and the encryption key $\mathbf{K_i}$ provided by the mobile operator

Reliably execute computational functions for the mobile device

2a

cf. [EffingRankl2008]

The Subscriber Identity Module (SIM)

- In GSM and UMTS since 1991, upcoming for WLAN
- Represents contract between subscriber & network operator
- Authenticates and authorizes **a "phone"** to **use** the network by linking it to a **subscription (authentication)**
- More and more called "Subscriber **Identification** Module" to reflect progress in the general field of **Identity Management (identification)**

2a

Exercise 4: Subscriber Identity Module (SIM)

b) What does the Subscriber Identity Module contain? Which of these contents are protected, which are not and why?

2

SIM Card Content (Extract)

- Protected data:
  - IMSI, PIN, PUK
  - A3, A8 crypto algorithms for signing and encryption
  - List of subscribed services
  - Language used by the subscriber
- Dynamic data:
  - Cell information
  - Frequency information
  - Dynamically generated (session) keys
  - Attributes of GSM login
  - User data (address book, telephone list, SMS memory)

2b

Exercise 2: Subscriber Identity Module (SIM)

c) Name other functionalities of the Subscriber Identity Module.

2

SIM: Functionality

- SIM serves as **„identity card“** for GSM cellular phone subscribers.
- SIM uniquely identifies the **issuer of the card –** important for the **billing of roaming subscribers** by roaming partner.
- SIM allows for **secure billing of roaming subscribers** through SIM-cryptography – important for card issuer.
- SIM contains additional **configuration data** of the GSM system.

2c

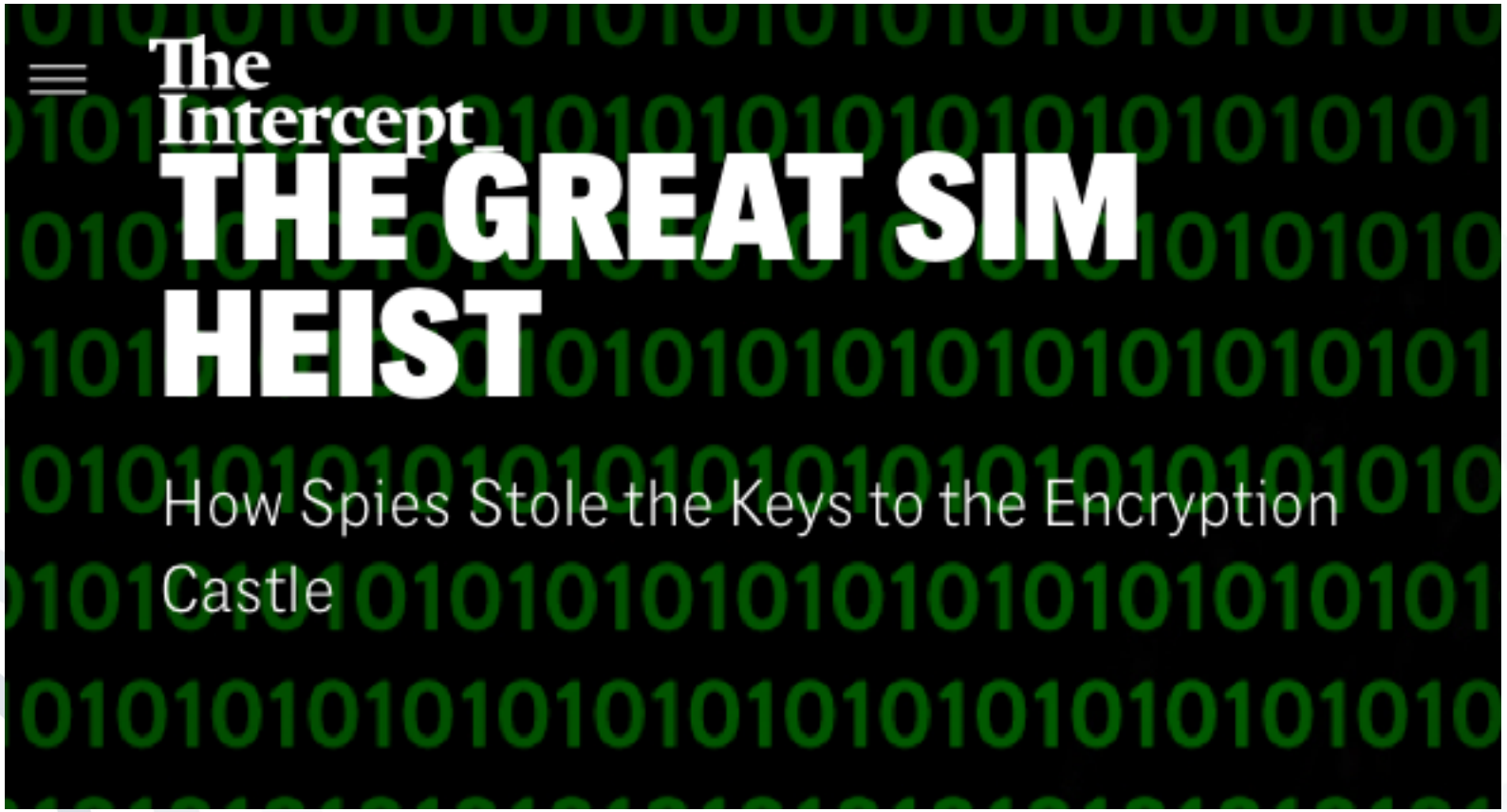
Smartcards for Mobile Communication

- **SIM**s are **Smartcards:**
  - **SIM cards** serve as security medium.
  - Tamper-resistance prevents counterfeiting.
  - Robust design
- Contain **International Mobile Subscriber Identity (IMSI)** for subscriber identification and the key $\mathbf{K_i}$ provided by the mobile operator
- Reliably execute computational functions for the mobile device

2c

cf. [EffingRankl2002]

- **Have you heard about the Gemalto SIM card hack?**



A the internal computer network of the largest manufacturer of SIM cards in the world, stealing encryption keys used to protect the privacy of cellphone communications across the globe, according to top-secret documents provided to *The Intercept* by National Security Agency whistleblower Edward Snowden.

The hack was perpetrated by a joint unit consisting of operatives from the NSA and its British counterpart Government Communications Headquarters, or GCHQ. The breach, detailed in a secret 2010 GCHQ document, gave the surveillance agencies the potential to secretly monitor a large portion of the world's cellular communications, including both voice and data.

The company targeted by the intelligence agencies, Gemalto, is a multinational firm incorporated in the Netherlands that makes the chips used in mobile phones and next-generation credit cards. Among its clients are AT&T, T-Mobile, Verizon, Sprint and some 450 wireless network

https://theintercept.com/2015/02/19/great-sim-heist/

Exercise 2: Subscriber Identity Module (SIM)

d) What is SIM Application Toolkit?
   (i) What does it do?
   (ii) Name application examples for SIM Application Toolkit.

2

SIM: Integration into Mobile Phones

- **ETSI GSM 11.11** [GSM2006] standard - specifies electrical as well as software interfaces between SIM and device.
- A **serial interface is** used for accessing the card.
- Communication through **SIM commands**
- Device can access **files** or execute **actions** through SIM commands.
- „SIM Application Toolkit“ (STK) allows for implementing **additional applications** on a SIM.

2d

SIM Application Toolkit – SAT

- Provides an interface for **Value Added Services** implemented on **programmable SIMs** for interacting with mobile devices
- **Standardised** 1996 as ETSI GSM 11.14, extended 1999 [GSM2006]
- **Controls** I/O, Telephony, Download
- Allows for **security functionality**
- „Living standard“

2d

SAT – Application Examples

- **Mobile Banking** and **Brokerage**
  - T-Mobile and T-Online SMS banking
- **Secure payment** via cellular phone
- **Authentication** of users trying to access servers
- **Location-based services**
  - ATM search, navigation
- **Security applications in general**
  - Mobile signatures

2d

Exercise 2e – Secure Element

- Describe the role and functionality of the UICC as a secure element.

2d

Exercise 2e – Secure Element

- In today's smartphones, a Secure Element can be found as a chip embedded directly into the phone's hardware, or in a SIM/UICC card provided by your network operator.
- It provides secure storage and execution environment.
  - Important functionality for e.g. secure mobile payment
  - Can provide software to "emulate" a normal bank card to process payment information

2d

Exercise 2e – Secure Element

- **Discussion:**
  - How to use the secure operations for communication with the outside world?
  - Imagine a scenario for electronic payment through a mobile phone. How would that work through the NFC?

  - An NFC capable device (running on “card emulation mode”) can communicate with an NFC terminal to exchange the data.

2d

Exercise 3: Universal SIM/USIM

a) What is a USIM?

3

Universal SIM – USIM

- **Standardised** in 3GPP TS 21.111 and 3GPP TS 31.102 [GSM2006]
- **Successor** of SIM in 3G networks (but 3G networks are downward compatible to many SIMs)
- Supports different **„virtual“ USIMs** and **SIMs** on one cards – i.e. multifunctional smartcard
- Specified as **„UMTS-SIM“**, to support authentication, authorisation and computation of future services

3a

Exercise 3: Universal SIM/USIM

b)Name the features introduced with the USIM.

3

USIM – Features

- Tiny computer - several mini applications
- A 3G (UMTS) handset equipped with a USIM card can be used to make video calls, assuming the calling area is covered by a 3G network;
- Better security (new encryption algorithm) for calls, data, and storage
- Larger, richer phonebook
  - thousands of contacts instead of a maximum of 255 in a SIM).
  - can contain email addresses, a second or third phone number, etc;

[Gemalto]

Exercise 3: Universal SIM/USIM

c) What is a UICC and how do USIMs relate to a UICC?

3

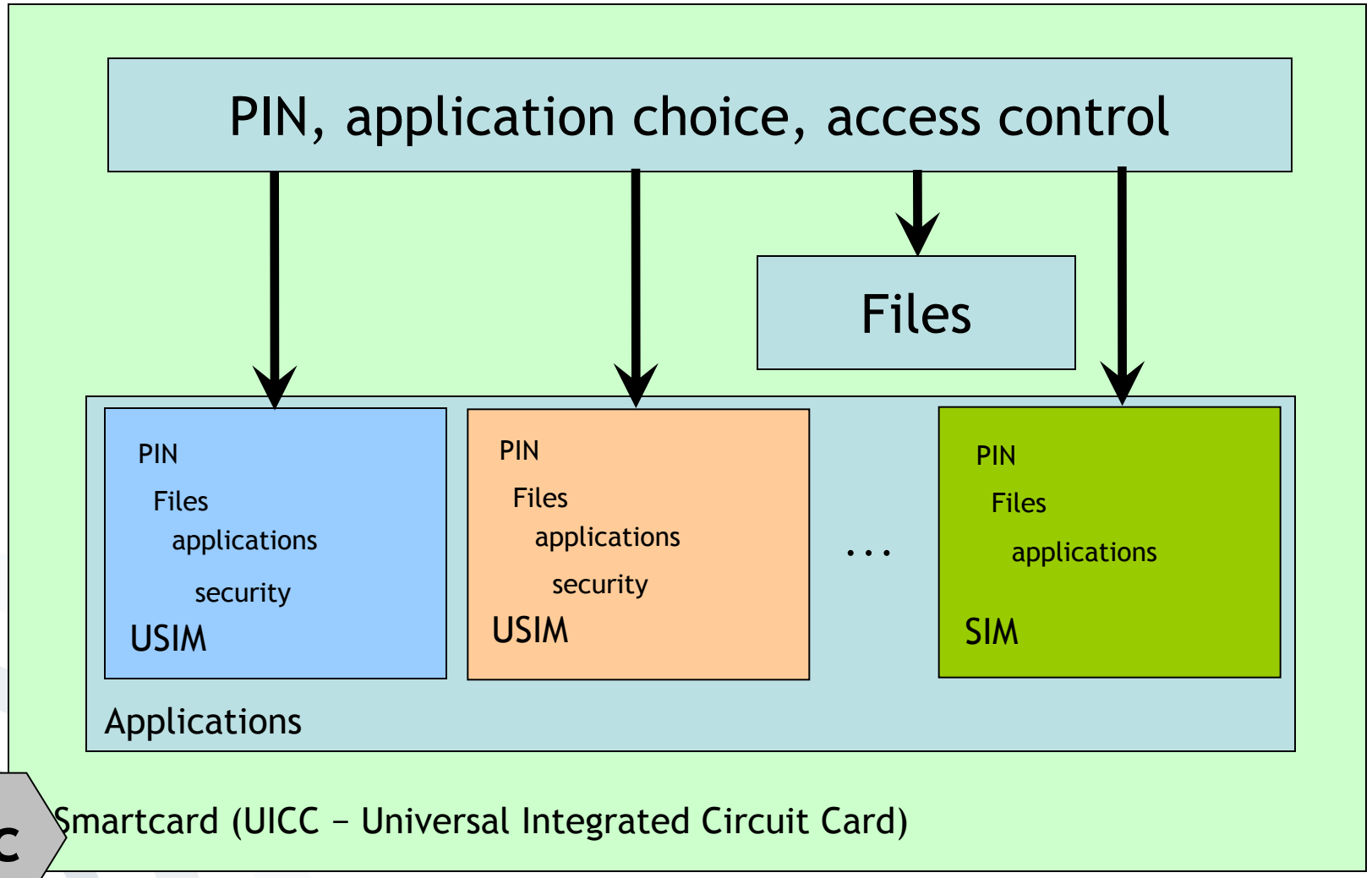
Exercise 3: Universal SIM/USIM

c) What is a UICC and how do USIMs relate to a UICC?

- The Universal Integrated Circuit Card (UICC) is the smart card used in mobile terminals in GSM and UMTS networks.
- In a GSM network, the UICC contains a SIM application and in a UMTS network it is the USIM application.

3

USIM on UICC – Structure



3c

Exercise 3: Universal SIM/USIM

d) Describe market opportunities and effects of competing USIMs.

3

USIM – Features

- **Support for multiple applications**
- **End-to-end security** from the USIM to the application
- **Authentication of the network** towards the USIM via cryptography
  ➲ **Multilateral Security** is possible!
- **Downward compatible** to SIM
- **Extended phone book** on card:
  - Email addresses
  - Multiple names & numbers for each entry
  - More memory
  - Standardised entries

3d

USIM – Visions of new Opportunities

Market entry of USIM „disguised“ **as SIM**
- ➲ UMTS activated by operator

Multiple USIMs – possibly **from competing providers** – can technically coexist on one card. Selection via menu on mobile device
- ➲ Reduction of operator switching cost

Switching to anonymous prepaid USIM as a privacy option when using privacy sensitive services?

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Guess the key technology behind (from the lecture)

http://www.gemalto.com/mobile/networks/on-demand-connectivity/pre-installed-sim

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Guess your answers

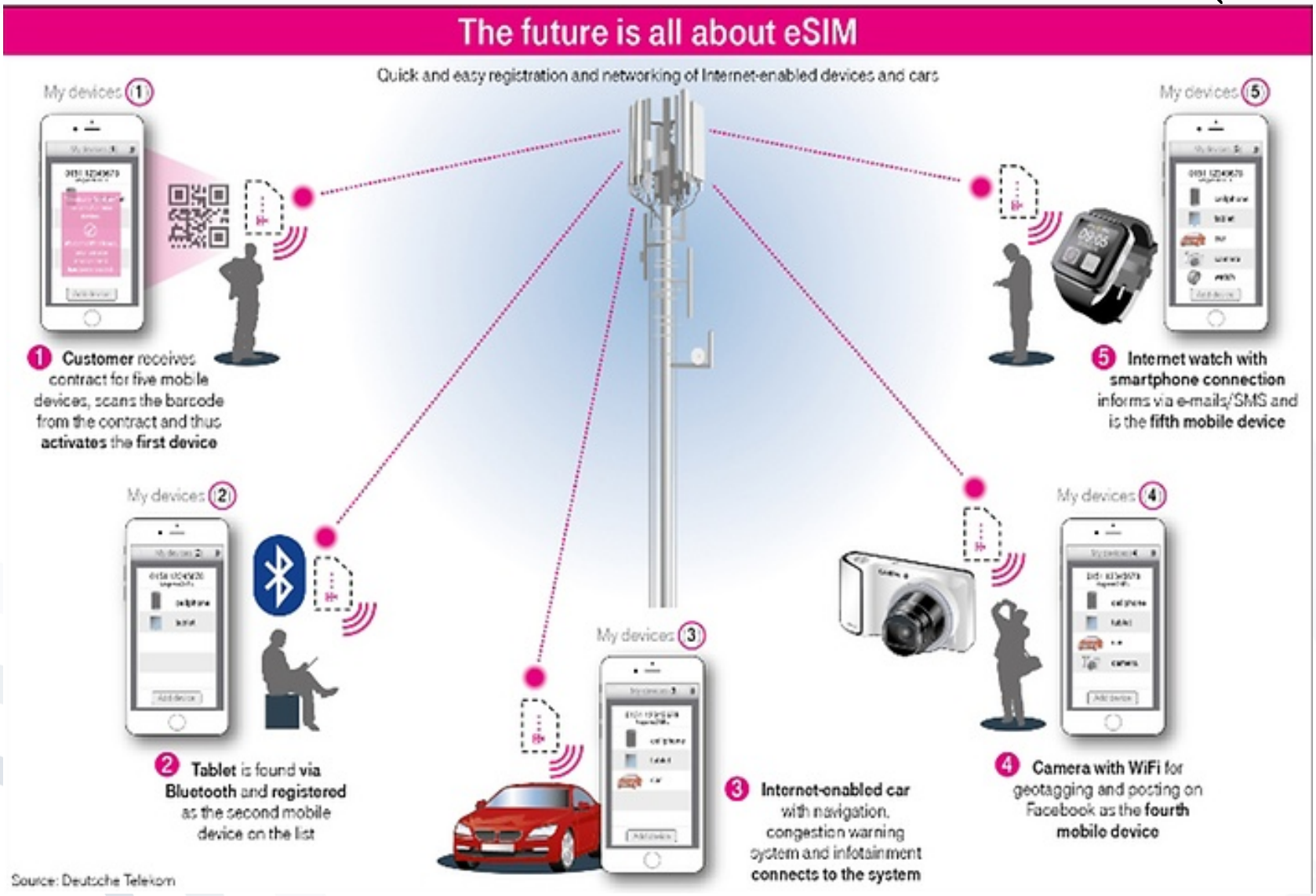
Go to **http://pingo.upb.de/413464**

eSIM
Embedded SIM (1)

- Characteristics of the embedded SIM (eSIM)
  - Embedded as a secure element in hardware (mobile devices, cars, household devices – to enable the deployment of IoT)
  - Likely implemented with a programmable ROM
  - Probably a “game changer”
    - Easy to switch providers/operators
    - Tariffs can be programmed/limited programmatically to devices, e.g. a 2-year contract can limit update to the card until the end of contract.
- Global standard being drafted by the GSMA, will require new terminal hardware

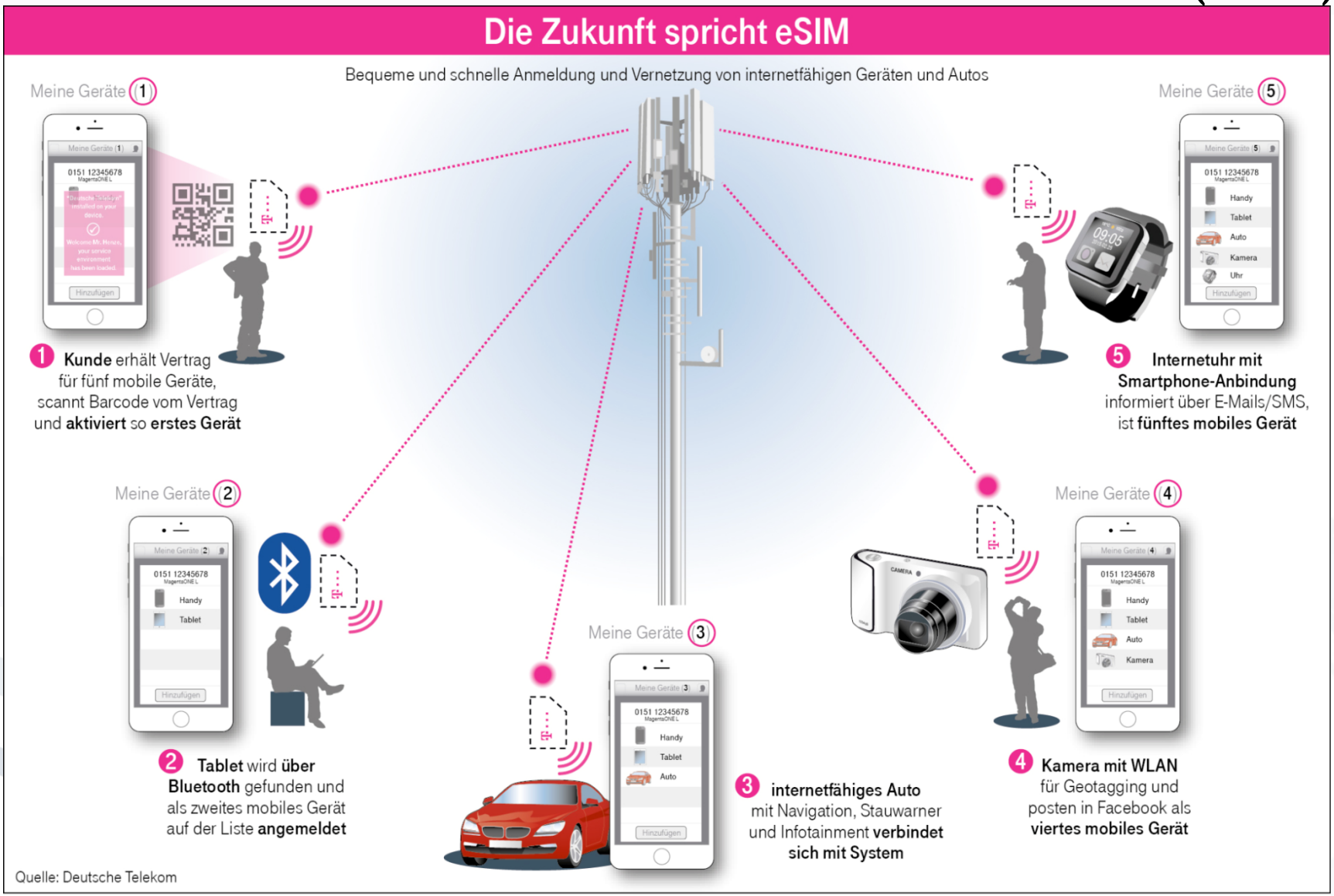
[Heise2015, T3n2015]

eSIM
Embedded SIM (2en)



[Telekom2015]

eSIM
Embedded SIM (2de)



[Heise2015]

Exercise 4 – General questions on Lecture 8

Exercise 4 (general questions)

b) Discuss about the eSIM market situation in Germany.

eSIM
Embedded SIM

- German market situation
  - Vodafone and O2 provide the first product/tariff with eSIM [Telefonica2016, Vodafone2016].
  - Telekom announced plan to introduce eSIM in 2016.
- Uncertainties
  - Fears of limited customer choice of operator/tariff (preselected list of operators)
  - Business models (shifting the device vendors)

Describe Apple iPad SIM, Google Fi, and eSIM.

Google's Fi Project

- Connectivity through different operators (since April 2015)
  - In cooperation with Sprint and T-Mobile in the US (joint SIM card)
  - Google is the contract partner to the subscriber.
  - Currently supported by Google's Pixel, Nexus 6P, Nexus 5X and Nexus 6 phones
  - Seamless switch between available Wi-Fi hotspots and the mobile network
- Simple price tariffs starting from $20 per month
  - All 135+ countries in Project Fi's network include the same great benefits, such as:
    - same rate pricing,
    - high speed data at the same $10/GB,
    - unlimited domestic SMS and calls
    - Unlimited "roaming" SMS and calls for 20¢ / minute.
  - Data tariff available in 120+ countries
  - Refund for the unused data each month
  - Group plans available, friends and family for additional $15 per month each

iPad Apple SIM

Apple SIM is available for purchase in Australia, Canada, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland, Turkey, the UK, and the US.

SIM contains credentials for several networks.

The customer must “activate” the desired network, which may dedicate the SIM to that network allowing no further change with that SIM.

When travelling abroad, the customer can use the same SIM card for a chosen mobile data tariff from “selected” operators in 90 countries worldwide.

Available since October 2014.

Costs in Germany:

SIM card for 5 EUR

1 GB of data for a month for 50 EUR.

In November 2016 supported by in cellular-enabled versions of its iPad Air 2, iPad mini 3, iPad mini 4, and iPad Pro tablets in Apple Retail Stores in Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

Exercise 4 – General questions on Lecture 8

Exercise 4 (general questions)

c) What are the differences between Google's FI and Apple SIM?

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Main difference?

Go to **http://pingo.upb.de/667100**

What do they have in common?

Open discussion: Google Fi and Apple SIM

Exercise 4: Mobile Devices

a) How can mobile devices be categorized?
   (i) Technical characteristics
   (ii) Application Aspects

Categorisation is possible by:

- Technical characteristics
- Application aspects
  - Lifespan of an application
  - Functional completeness (Is the functionality comparable to a desktop PC/Laptop?)
  - Size of the device
  - Security features

4a

Categorisation of Mobile Devices

Technical Characteristics

Hardware independence

- Independent devices
- Devices with external communication
- Devices with external security modules
- Devices with external memory

Operating system – Characteristics

- Memory security, file security, access control
- Security module support, secure I/O, program and system integrity

4a

Categorisation of Mobile Devices

Application Aspects 1

- Lifespan of an application
  - Battery consumption, amount of data, and size of memory
  - Data integrity, amount of communication, and costs
- Completeness of the functionality for the end-user
  - Information / Reaction
  - Limitations due to device size
  - Feature Sets

4a

Categorisation of Mobile Devices

Application Aspects 2

Device size

- Small / integrated devices
- „Pocket-sized“
- „Tablet-sized”
- „Laptop-sized“

Access to the security module

- Data integrity, encryption
- Digital signatures
- Access control, authentication

4a

Exercise 4: Mobile Devices

b) Name four components of mobile devices. Which two of these components do considerably determine the size of a mobile terminal?

4

- Main physical components of Mobile Devices
  - Accumulators
  - Processors, Memory, and Storage
  - Display
  - Means for I/O

Size of a mobile Device

- The size of a mobile terminal is considerably determined by its:
  - Input Facilities (e.g. keyboard)
  - Output Facilities (e.g. display)

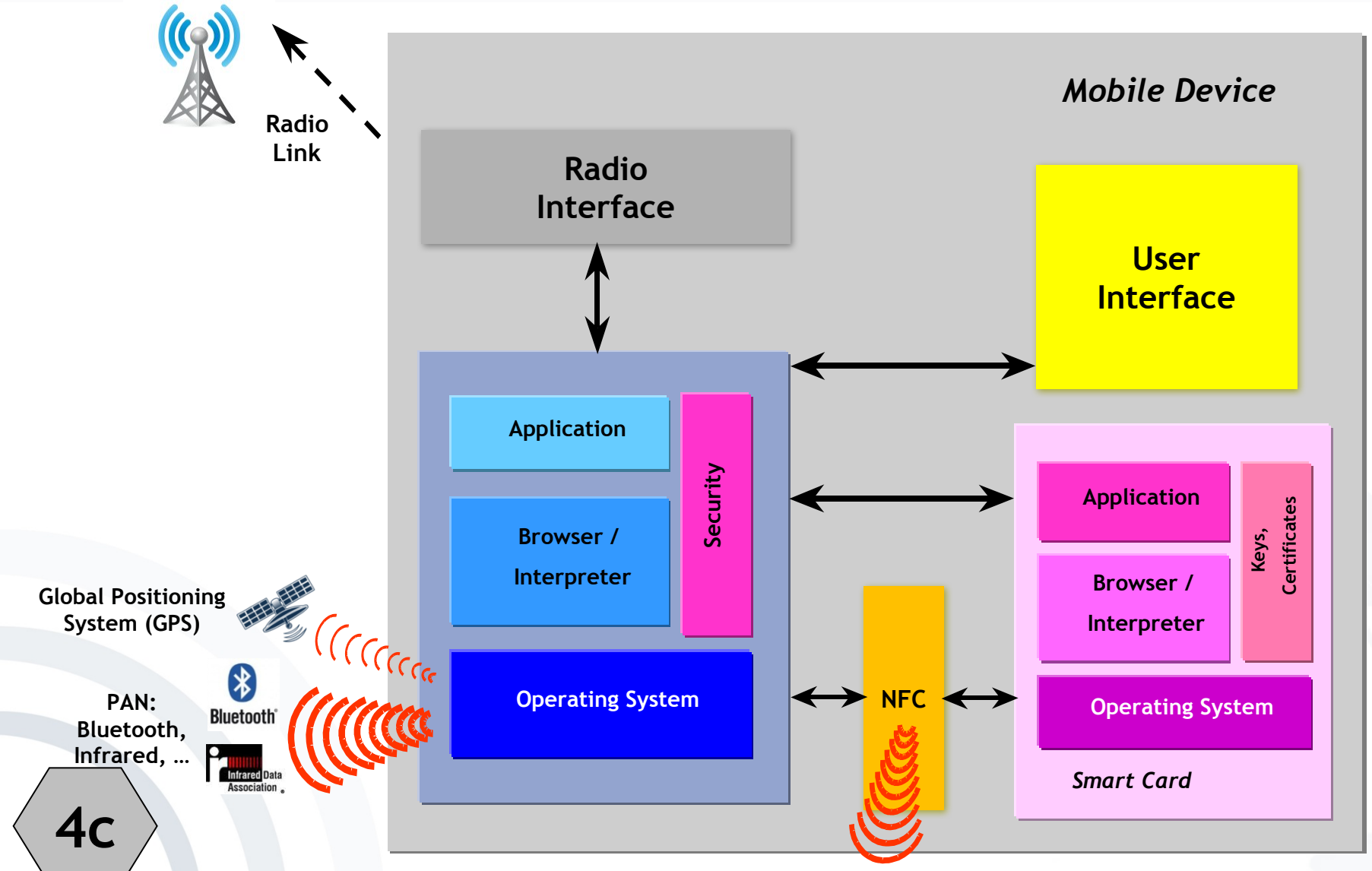
➲ Separation of components (e.g. display in the watch, head-mounted-displays)

Exercise 4: Mobile Devices

c) Describe the functional architecture of a mobile device.

4

OS – Functional Architecture



Based on [Posegga2001]

Exercise 5: Personal Area Networks (PAN)

a) Personal Area Networks (PAN) – what are they good for, what do they do?

5

Personal Area Network (PAN)

- Personal environment, short range
- ***Purpose***: Connection of devices in short range, for example mobile device and printer.
- Replaces cable-connections:
  - **I**nfra**r**ed **D**ata **A**ssociation (IrDA)
  - Bluetooth
  - Near Field Communication (NFC)

5a

Exercise 5: Personal Area Networks (PAN)

b) Please do briefly describe the related technologies IRDA and Bluetooth. Name the advantages and disadvantages of both IRDA and Bluetooth.

5

Personal Area Network (PAN)
Infrared

- IrDA: Infrared Data Association (1993):
- Standardized infrared-protocols
- Asynchronous, serial connections up to 115 kbit/s (Serial Infrared) or 4 Mbit/s (Fast Infrared)
- Point-to-Point
- Protocol-family for various purposes

- Exemplary applications:
  - Transmission of mobile business cards
  - Sales data extraction from cigarette vending machines
  - Connection between mobile and laptop
  - Wireless printing
  - Remote control for consumer electronics, e.g. TVs

5b

Personal Area Network (PAN)

Infrared-Transmission

- Attributes:
  - Wireless
  - Range of up to 10 meters
  - Illumination-angle 15° -30°
- Disadvantages:
  - ***Sounding:*** If the infrared-ray misses the target
  - Optical connection required
  - Short interruptions of the optical connection, e.g. between laptop and mobile phone in trains, lead to complete network-interruption.

5b

Personal Area Network (PAN)

Bluetooth

- Frequency range of 2.4 GHz
- Simple and cheap possibility to set up ad-hoc networks of limited range (up to 10 meters)
- No official standard, but de-facto-standard
- v4.2 (2014) improved speed, privacy, and connectivity (support for the Internet of Things)
  - V5 (to come) promises higher speeds (up to 2 MBps) and longer distances (up to 120m)
- Broadly supported by related industries:
  - Computer hardware
  - Software
  - Consumer electronics
  - …

5b

Bluetooth™

Personal Area Network (PAN)

Popular Bluetooth Applications

Sound transmission
(to earphones, headphones
or Hi-Fi equipment)

Wireless communications between devices
(Bluetooth-Headset)

5b

a) What are the advantages and disadvantages of mobile operating systems unavailable to other device manufacturers?

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Mobile OS unavailable to other device manufacturers

- Originally, most mobile phone manufacturers used their own “closed” operating systems for their mobile devices.
- Later, more and more platforms switched to more open and interoperable operating systems (e.g. Windows CE, Symbian OS, Android).
- Some manufacturers (still) rely on own OS, e.g. RIM Blackberry OS, Apple iOS.
- ***Advantage:*** Tend to be not as much affected by malware than “open” operating systems
- ***Disadvantage***: Interoperability - Less flexible, as 3rd-party software cannot be easily installed and executed

6a

b) Name two mobile operating systems unavailable to other device manufacturers and two manufacturer-independent mobile operating systems.

6

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Manufacturer-independent mobile OS

- Linux: LiMo (Linux Mobile), Openmoko Linux, Qt Extended (Qtopia)
- Symbian platform
  - Latest release: “Nokia Belle Feature Pack 2“ for Symbian^3 devices
- Android (by Open Handset Alliance)
  - Latest release: 7.1 (Nougat)
- Windows Mobile
  - Latest release: Windows 10 Mobile 1607 (10.0.14393.479)
- Windows Phone
  - Latest release: Windows Phone 8.1
- Maemo (by Nokia) → MeeGo (by Nokia, Intel) → Sailfish OS (by Jolla)
  - Latest release: Sailfish OS 2.0.5.6 (Haapajoki) (November 2016)
- Tizen (by Samsung, Intel, Linux Foundation)
  - Latest release:3.0 (September 2016)
- Firefox OS (by non-profit organisation Mozilla)
  - Latest release: 2.2.0 (April 2015)
- China-Focused Mobile OS
  - Currently under development by Taiwan-based HTC [WSJ2013]

6b

= Linux-based

Mobile OS unavailable to other device manufacturers

Examples

Originally, most mobile phone manufacturers used their own “closed” operating systems for their mobile devices.

Palm OS (Garnet OS)

Latest release: Palm OS Cobalt 6.1

Apple *iOS* (Unix-based)

Latest release: iOS 10.1

BlackBerry OS

Latest release: BlackBerry OS 10.3.3

Newer Blackberry models *(PRIV, DTEK60, and DTEK50)* run on Android

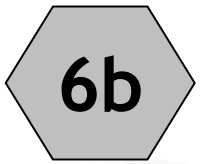
LuneOS (formerly WebOS, initially developed by Palm, later HP)

Latest release: LuneOS Caffè Tobio

Not to be confused with Palm OS (now: Garnet OS) that was also initially developed by Palm

Samsung bada

Latest release: v2.0, e.g. on Samsung Wave 3 S8600 (discontinued 2013)



c) When mobile operating systems allow the execution of 3rd-party software, what are the threats resulting from this for the user?

6

Current Threats from Malware on Mobile OS

- Many mobile operating systems allow the execution of 3rd-party software:
  - Malware can be executed on mobile operating systems, either intentionally or by security leaks inside the mobile operating system (exploits).
- Possible threats for the user are:
  - Device malfunction
  - Loss of data (malware erasing data)
  - Loss of money (e.g. malware sending SMS to premium services)
  - Shorter battery runtime (more processing/resource usage)

6c

Beginnings of Mobile Malware

- ***09/2000***: Liberty Horse Trojan
- ***12/2000***: Telefonica SMS Mailer
- ***08/2001***: Flooder sends unwanted SMS
- ***09/2001***: Phage erases data on Palm devices
- ***02/2003***: Nokia V-Card exploit
- ***09/2004***: First Symbian OS malware
- …

Strong growth of Mobile Malware

- The number of malware programs masquerading as legitimate mobile apps grew by more than 600 percent in 2012
- Most popular target: Android

[ATD2013]

6c

Malware goes Mobile: Timeline of Mobile Threats 2004-2016

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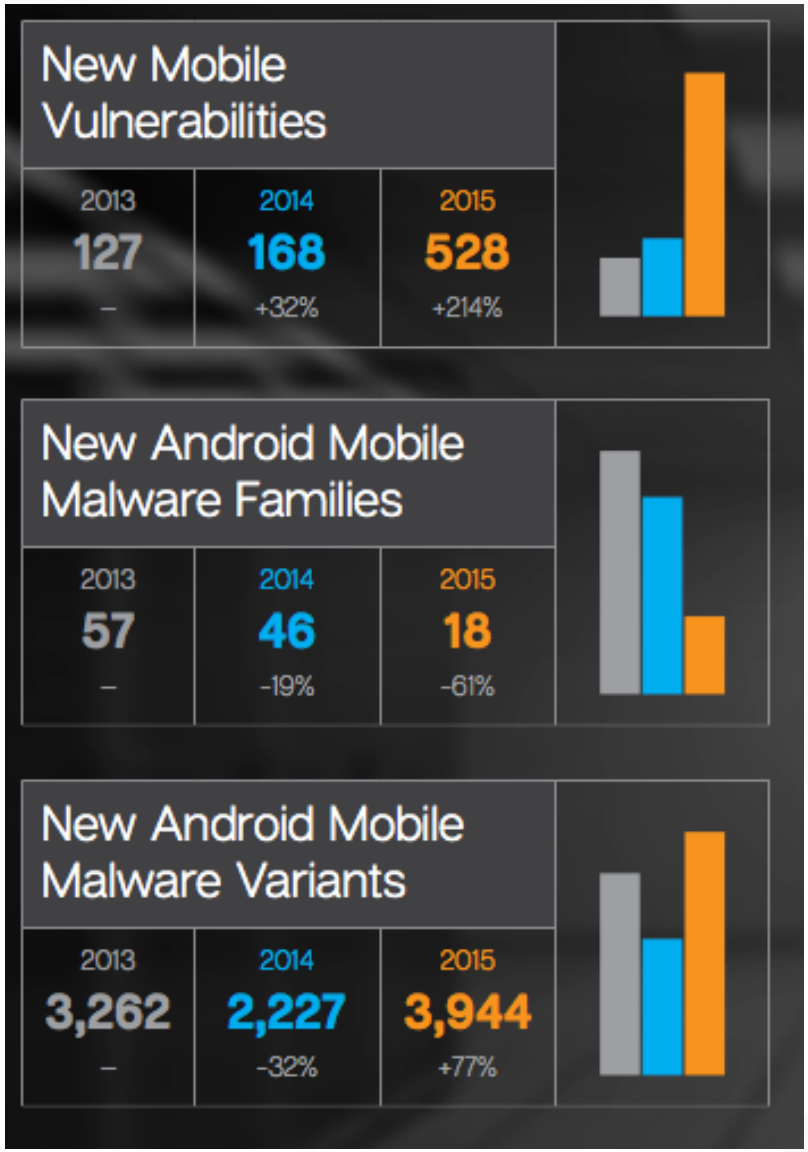
Mobile Threats in Numbers

	2013	2014	2015
Total Apps Analyzed	6.1 Million	6.3 Million	10.8 Million
Total Apps Classified as Malware	0.7 Million	1.1 Million	3.3 Million
Total Apps Classified as Grayware	2.2 Million	2.3 Million	3.0 Million
Total Grayware Further Classified as Madware	1.2 Million	1.3 Million	2.3 Million
Malware Definition	Programs and files that are created to do harm. Malware includes computer viruses, worms, and Trojan horses.		
Grayware Definition	Programs that do not contain viruses and that are not obviously malicious, but that can be annoying or even harmful to the user, (for example, hacking tools, accessware, spyware, adware, dialers, and joke programs).		
Madware Definition	Aggressive techniques to place advertising in your mobile device's photo albums and calendar entries and to push messages to your notification bar. Madware can even go so far as to replace a ringtone with an ad.		



Mobile Threats in Numbers

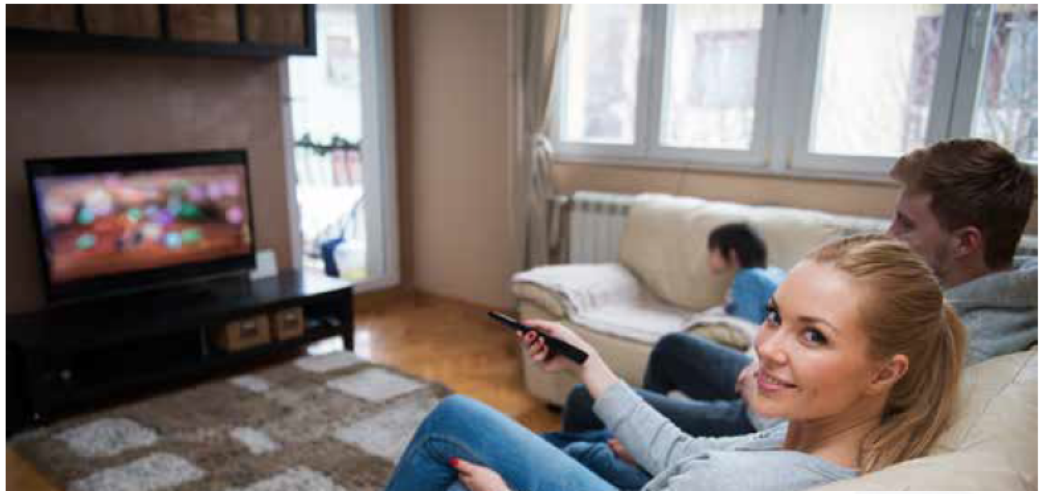
Is Your Phone Monitoring What You Watch on TV?

In our previous threat report, we talked about apps that were grabbing data from your phone without your knowledge. Now, a company from India has released an advertising software developer kit (SDK) called SilverPush that uses your phone's microphone to listen for near-ultrasonic sounds placed in TV, radio and Web advertisements. Once SilverPush detects the signal, it collects data from your device and sends information about your device back to the advertiser. While this is not a piece of malware, it is a huge concern from a privacy perspective. It collects personal information from your device, including, but not limited to:

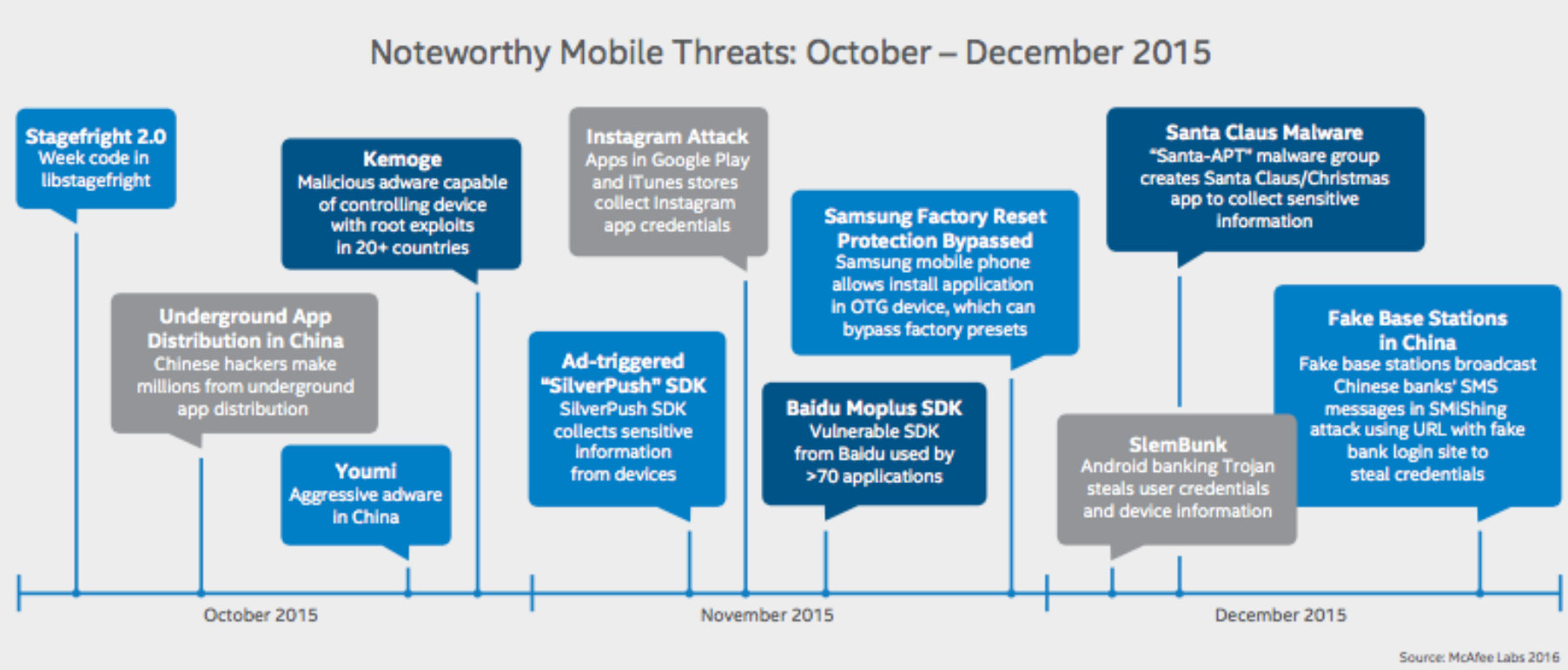
- IMEI number (a unique number that identifies your phone)
- Operating system version
- Location
- Potentially the identity of the owner
- The user's television, radio and Web behavior

The SilverPush Problem
Your phone could be monitoring what you watch on TV without your knowledge or permission.

SilverPush is not a standalone app, but is embedded as part of another application and typically runs without the user's consent. If an application on your mobile device is detected as containing SilverPush, the best solution is to remove that application from your device.

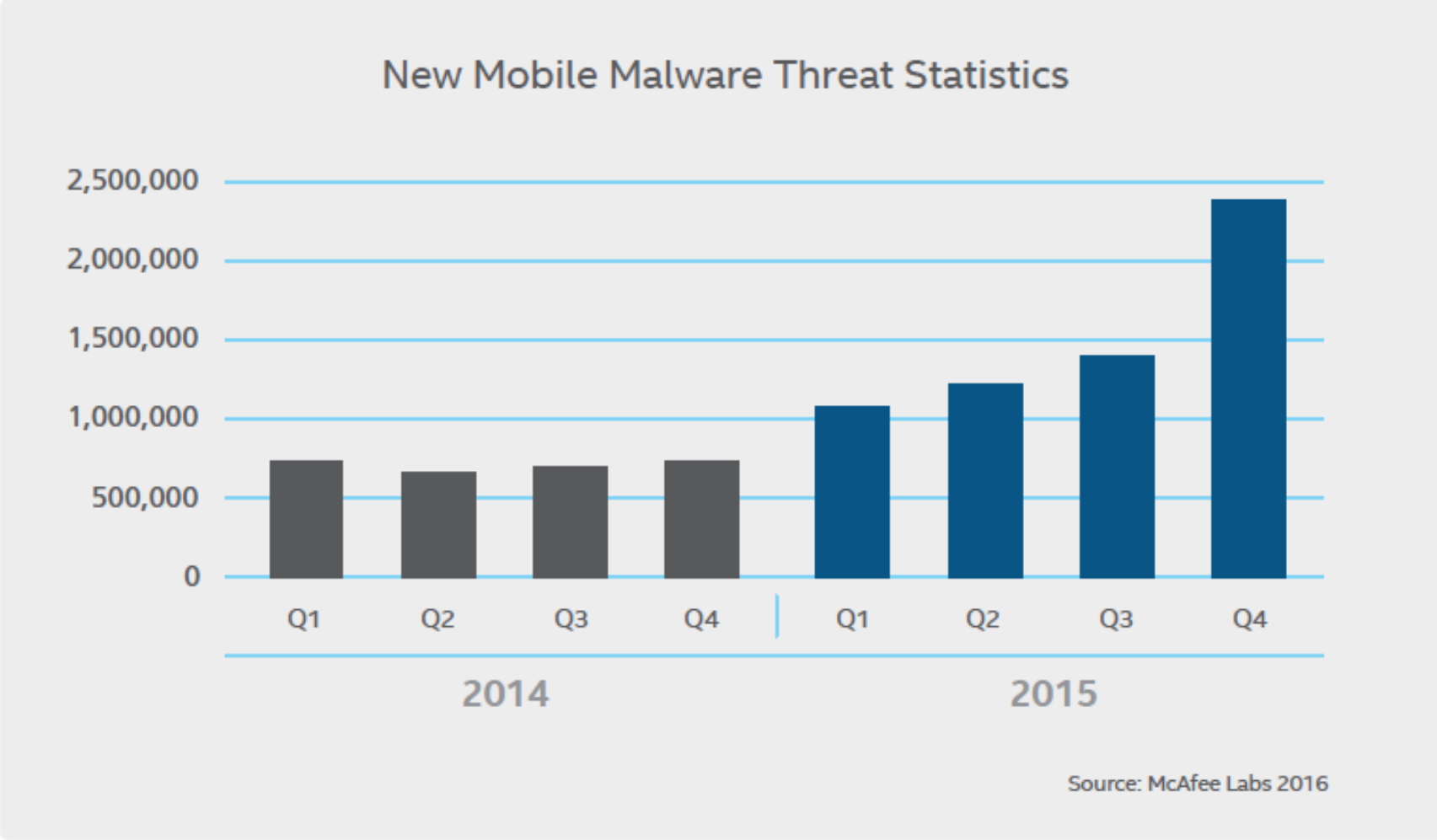


Threats 2014/2015



[McAfee2016] B. Snell *et al.*, 2016. Mobile Threat Report: What's on the Horizon for 2016

Dangers on the App Stores



[McAfee2016] B. Snell *et al.*, 2016. Mobile Threat Report: What's on the Horizon for 2016

d) What are the security precautions and countermeasures available in mobile operating systems?

6

Security Precautions and Countermeasures

- Memory protection
  - Processes are not able to access the memory of other processes.
- File protection
  - Encryption
  - Access control
- Access controls
  - Definition of access rights and monitoring of their enforcement.
- Support for security modules
- Secure I/O
- Code integrity management: Integrity of programs is checked before the are started by e.g.
  - Checking certificates
  - Proof Carrying Code
- Additional Security Software may be needed, e.g.
  - Virus scanners
  - Firewalls

6d

Security of Mobile Operating Systems

Security measures	Apple iOS	Google Android	BlackBerry	Windows Phone
Access-control options	PIN, passcode, fingerprint	PIN, passcode, swipe, FaceLock	PIN, smartcard	PIN, passcode
MDM-configurable PIN/passcode policy	Yes	Yes	Yes	Yes
Full-device encryption	iPhone 3GS+ every iPad	Selected tablets (Android 3+) Selected phones (Android 4+)	All BlackBerry phones	Windows Mobile 6.5 Windows Phone 8
SD card encryption	No SD cards	OEM proprietary	Yes	No
Remote wipe	Removes encryption keys	Resets to factory defaults	Removes encryption keys Optionally scrubs memory	Varies by OEM/OS version

6d

[SM14]

Security of operating systems

Feature / OS	iOS	Android	Firefox OS	Windows Phone	BlackBerry 10
On-device encryption	Yes (3rd party software may attempt brute-force attacks on password)	Yes, but insecure on Qualcomm devices	No	8+	Yes (3rd party software may attempt brute-force attacks on password)
External storage encryption	External storage not available	6+	?	8.1+ Apps and data only	Yes
Sync to cloud communication encryption	Yes	2.3.4+	?	7.10.7720.0+	Yes
Remote device location tracking	Yes	Yes	No	Yes	Yes
Remote device locking and/or data wipe	Yes	2.2+	No	Yes	Yes
End-to-end encrypted push notifications	Possible since iOS 7	Possible	?	Possible	?
SSH Client	Yes	Yes	?	Yes	Yes

Adapted from [Wiki2016]

Exercise 7: Concepts of Mobile Operating Systems

a) What is an OS and what are its main goals?

What is an operating system (OS)?

- An OS is a program that serves as a mediator between the user and the hardware.
- It enables the users to execute programs
- *Other properties:* Multi-user, multi-thread, high availability, real-time, …

- ***Primary goal of an OS***: Easy usage of the actual hardware
- ***Secondary goal of an OS***: Efficient usage of the hardware

7a

[SilberGalvin1999]

Exercise 7:
Concepts of Mobile Operating Systems

b) Name three functions of the operating system and state two examples (exemplifications) for each of these functions.

7

OS Functions

- Controlling and sharing of resources
  - Computation time, real-time processing
    “Who is computing how much? How long does it take?”
  - Memory (RAM, Disk)
    “Who gets which part of the memory?”

- Security functions
  - Protection of the data (memory, hard disk):
    “Who is allowed to access resources?”
  - Process protection (computation time, code, isolation):
    “Who is allowed to compute?”
  - Security module support

- Communication
  - Allocation of I/O-Resources
  - Processing of the communication
  - User interface (UI)

7b

Exercise 7: Concepts of Mobile Operating Systems

c) What is a process? What does it do, what does it use and how is the mobile operating system involved?

Process

- A process is a program “in operation”.
- A process uses resources, such as CPU time, memory, files, and I/O devices.
- The resources of a process are allocated while it is created or when it is running.
- The operating system has to manage the process (creation, resource distribution, etc.).

Components of a Process

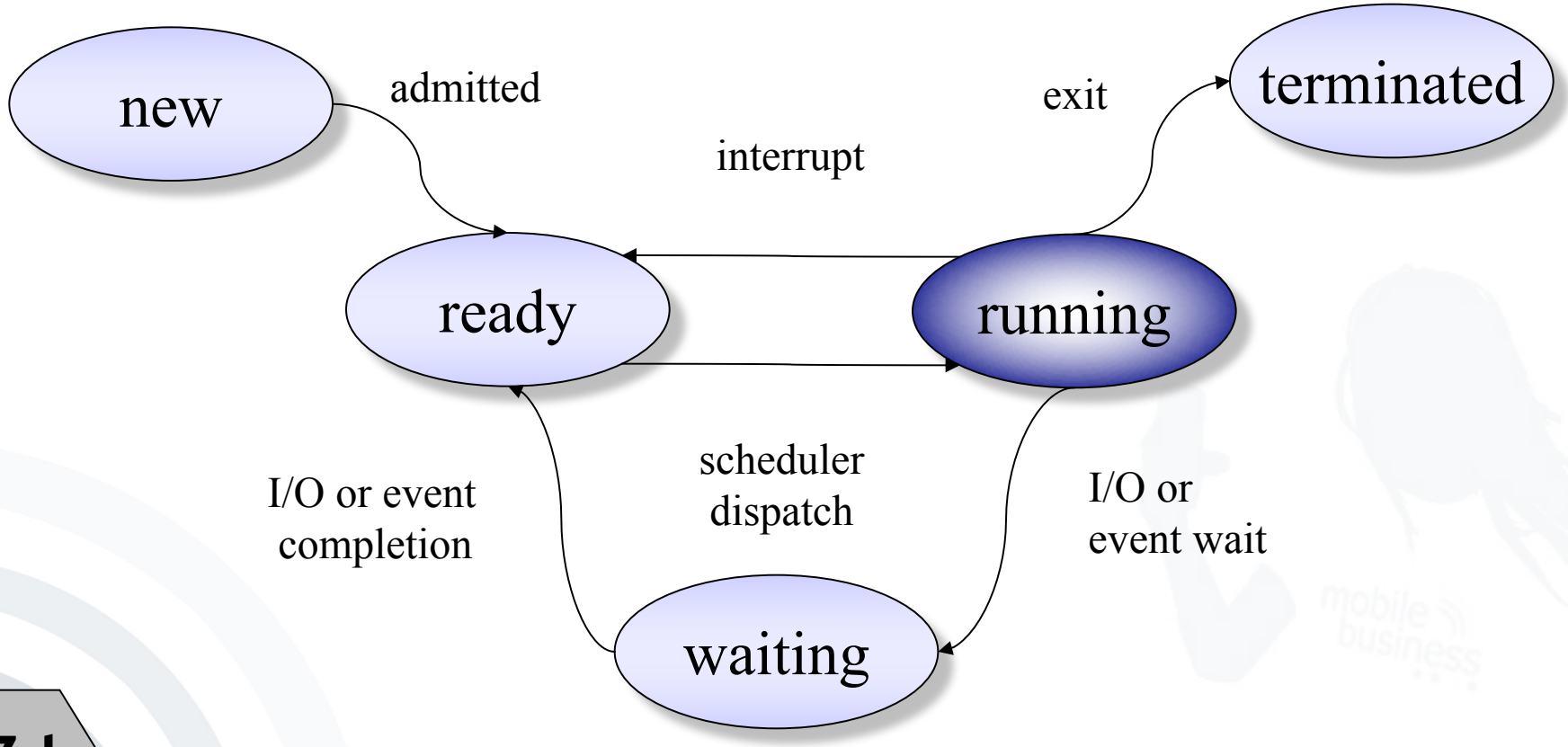
- More than simple code!
- Program counter: Indicates on which point in the code the process resides.
- Contents of the process registers:
  - ***Stack:*** Contains temporary data, such as subroutine parameters or return addresses, etc.
  - ***Data section:*** Contains the global variables
  - ***Heap:*** Dynamically allocated memory

Exercise 7:
Concepts of Mobile Operating Systems

d) Which are the states of a process?

7

States of a Process



7d

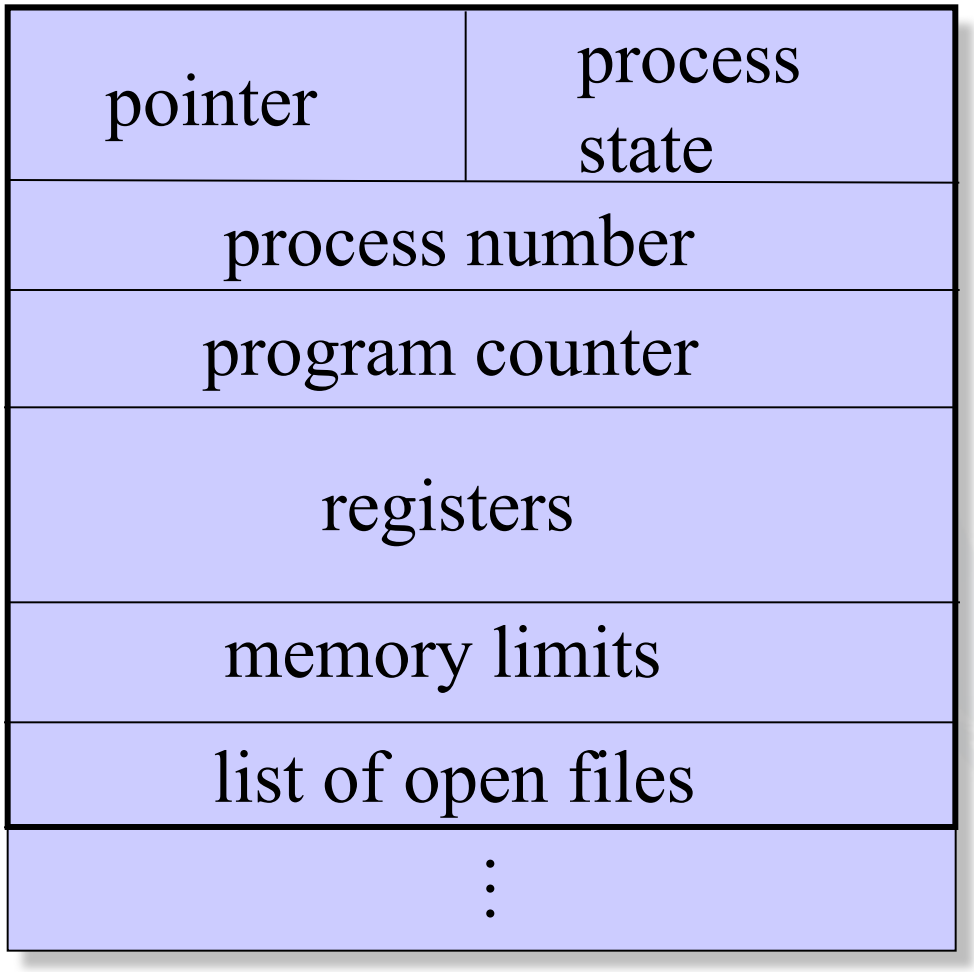
[SilberGalvin1999]

States of a Process

- **New:** Process is created.
- **Ready:** Process is waiting for being executed.
- **Running:** Process is running.
- **Waiting:** Process is waiting for results:
  - Completion of an I/O-operation
  - An event
- **Terminated:** Process is terminated.

Abstracted View on a Process: Process Control Block (PCB)

- Abstracted representation of the contents of a process control block (PCB), needed by an operating system.



[SilberGalvin1999]

7d

Abstracted View on a Process: Process Control Block (PCB)

- **Process State**: *new*, *ready*, *running*, *waiting*, …
- **Program Counter**: Address of the next command to be executed
- **CPU Registers:** Accumulator, Index Register, Stack Pointer and general registers
- **Information for:**
  - CPU-Scheduling
  - Memory-Management
  - Accounting
  - I/O Status

7d

Literature

- This set of slides is based upon the following lectures:
  - ***Lecture 8:*** Smartcards and Related Application Infrastructures
  - ***Lecture 9:*** Mobile Devices
  - ***Lecture 10:*** Concepts of Mobile Operating Systems
  - ***Lecture 11:*** Market Overview of Mobile Operating Systems and Security Aspects

Regarding the Case Study with *pwc*

- The *pwc* to hold a presentation on 10 January with assignments
- Next session with *your* presentations will take place as scheduled on the Tuesday 17. Jan 17 from 10-12h:
  - Here at the University, or
  - At the *pwc* offices in the city.
- Follow the news in our website (m-chair.de)!
  - We may require registration for the event
- Use this opportunity to your benefit

pingo.upb.de → 140523

mobile business

Thank you!

Contact: mb1@m-chair.de

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