mobile business

Lecture 11

Market Overview of Mobile Operating Systems and Security Aspects

Mobile Business I (WS 2019/20)

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Overview

- The market for mobile devices and mobile OS
- Mobile OS unavailable to other device manufacturers
  - Overview
  - Palm OS
  - Apple iOS (Unix-based)
- Manufacturer-independent mobile OS
  - Overview
  - Symbian platform (by Symbian Foundation)
  - Embedded Linux
  - Android (by Open Handset Alliance)
  - Microsoft Windows CE, Pocket PC, Pocket PC Phone Edition, Mobile
  - Microsoft Windows Phone / 10 Mobile
  - Firefox OS
  - KaiOS
- Attacks and countermeasures

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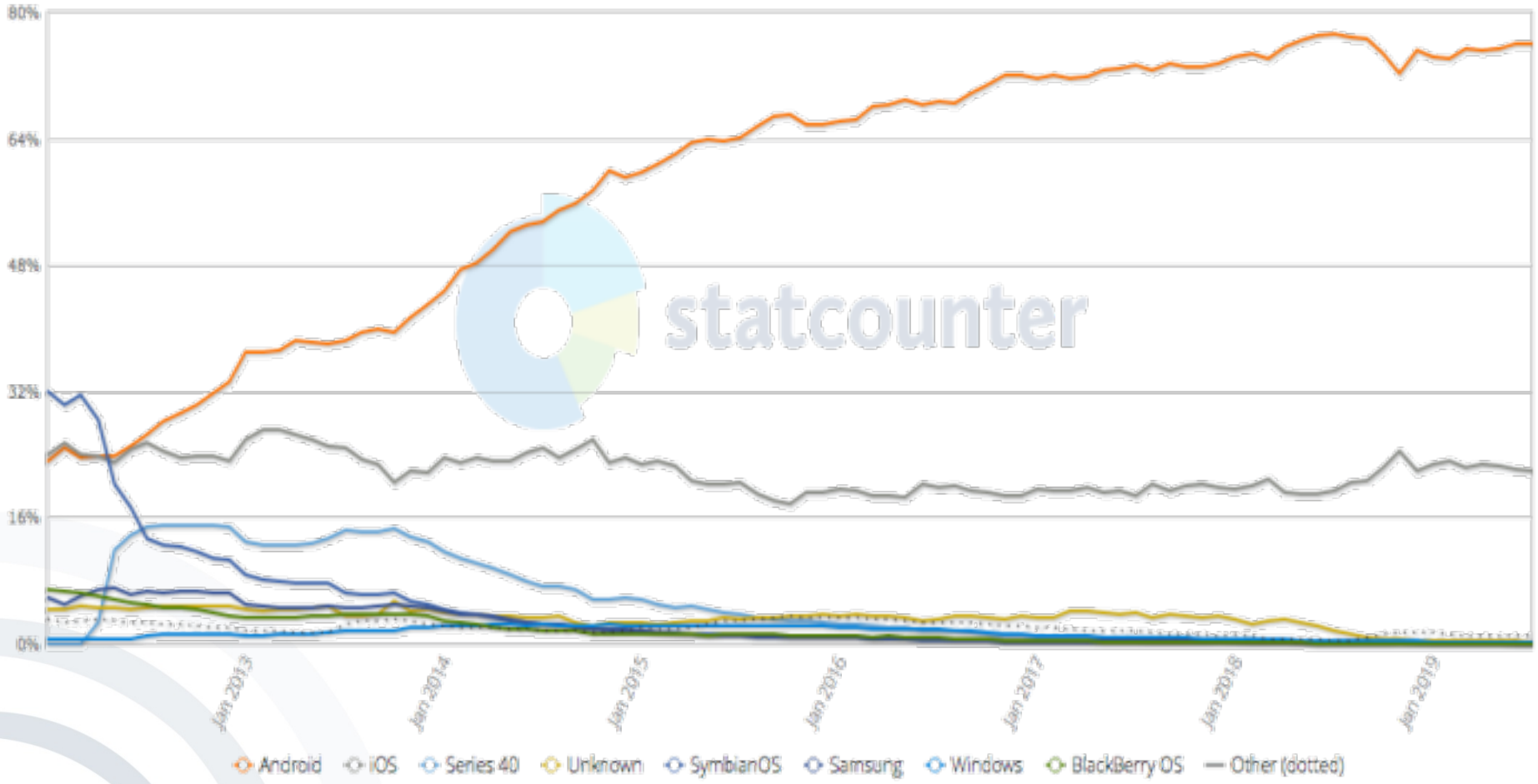
Worldwide smartphone sales to end users by operating system (2012-2019)



OS

[Statcounter]

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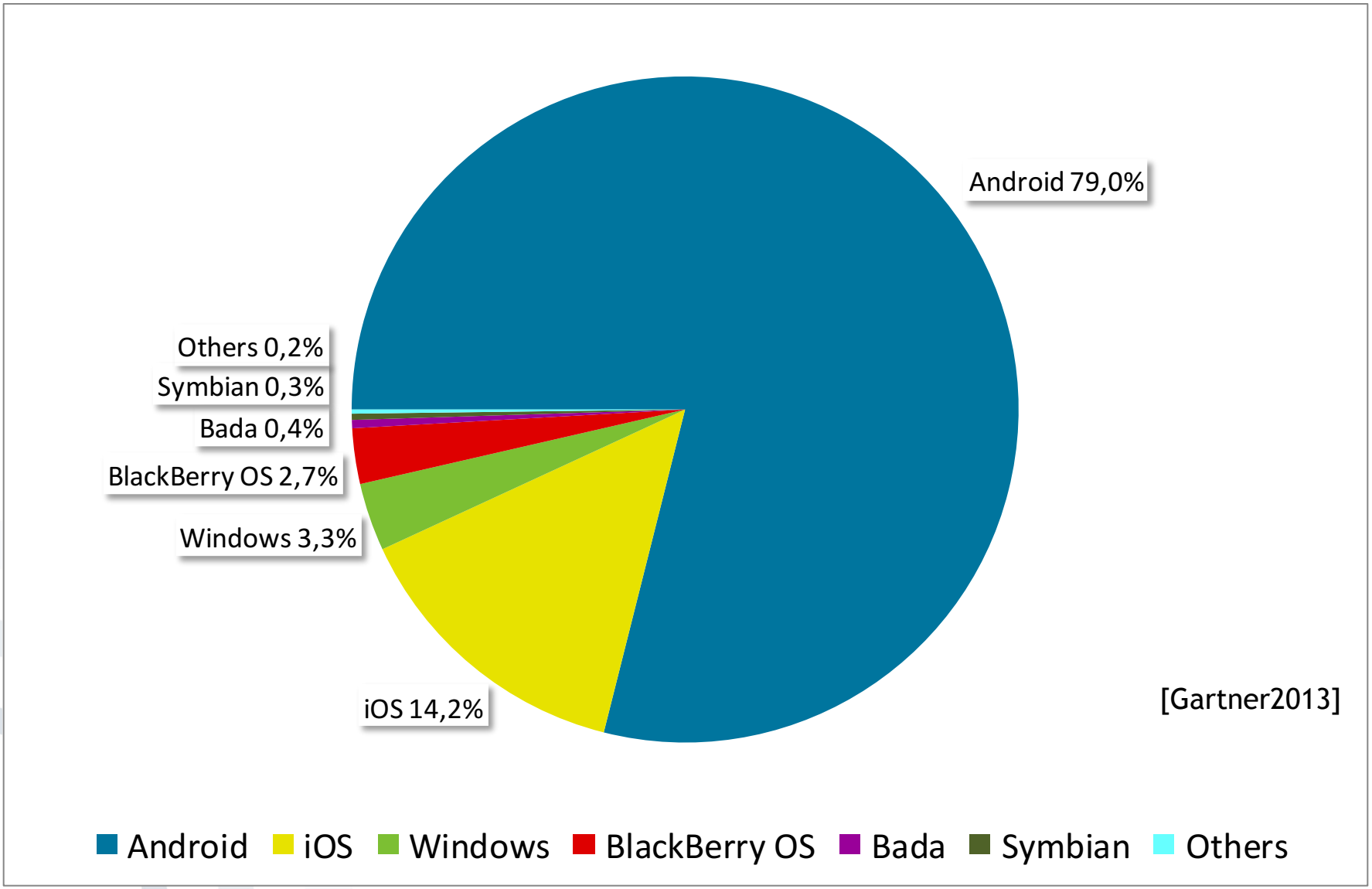
Worldwide smartphone sales to end users by operating system (2017/18)

Operating System	1Q18 Units	1Q18 Market Share (%)	1Q17 Units	1Q17 Market Share (%)
Android	329,313.9	85.9	325,900.9	86.1
iOS	54,058.9	14.1	51,992.5	13.7
Other OS	131.1	0.0	607.3	0.2
Total	**383,503.9**	**100.0**	**378,500.6**	**100.0**

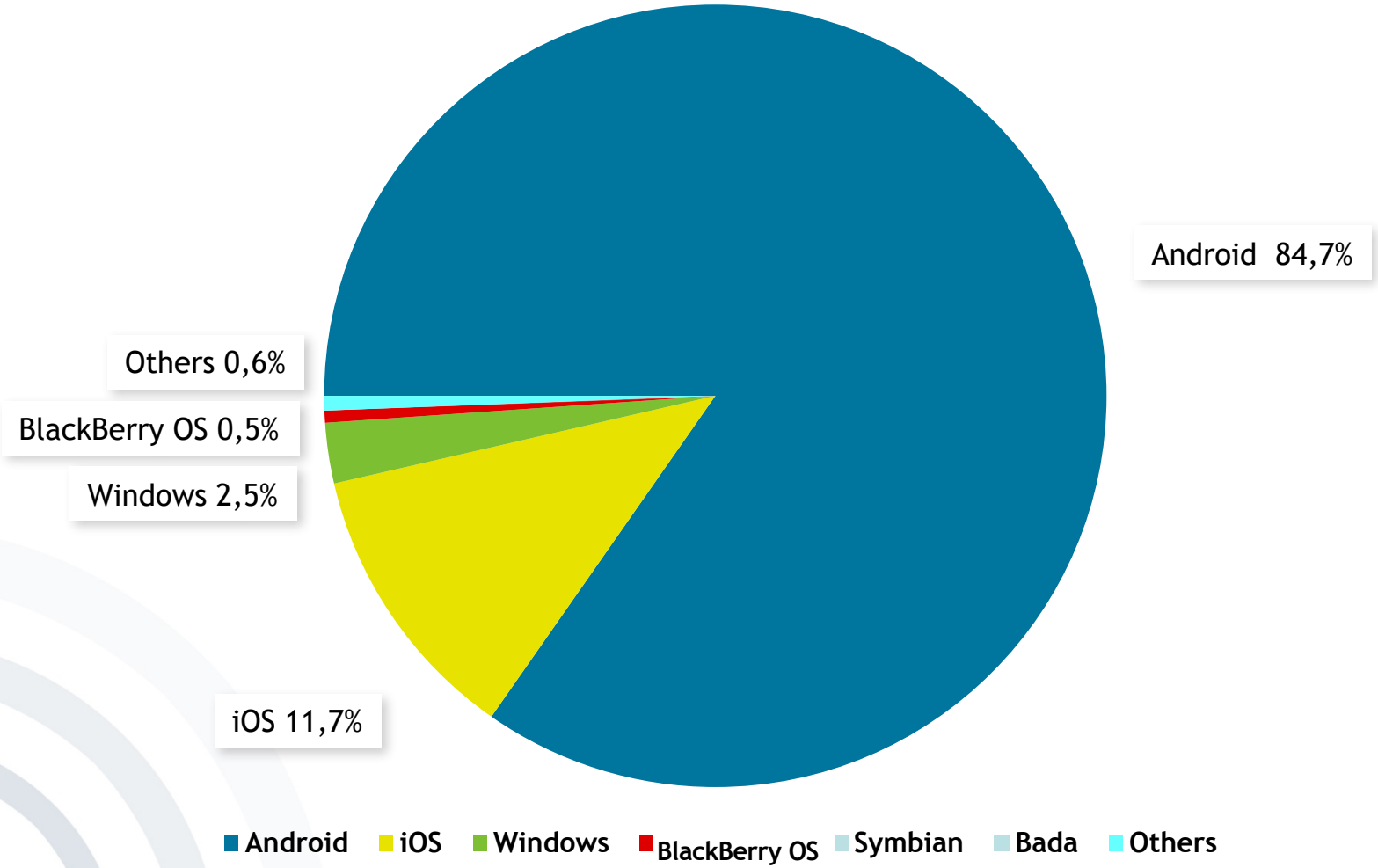
Operating System	2Q18 Units	2Q18 Market Share (%)	2Q17 Units	2Q17 Market Share (%)
Android	329,503.4	88.0	321,848.2	87.8
iOS	44,715.1	11.9	44,314.8	12.1
Other OS	112.1	0.0	433.1	0.1
Total	374,330.6	100.0	366,596.1	100.0

[Gartner2018]

Worldwide smartphone sales to end users by operating system (Q2 2013)



Worldwide smartphone sales to end users by operating system (Q2 2014)



[Statista 2014a]

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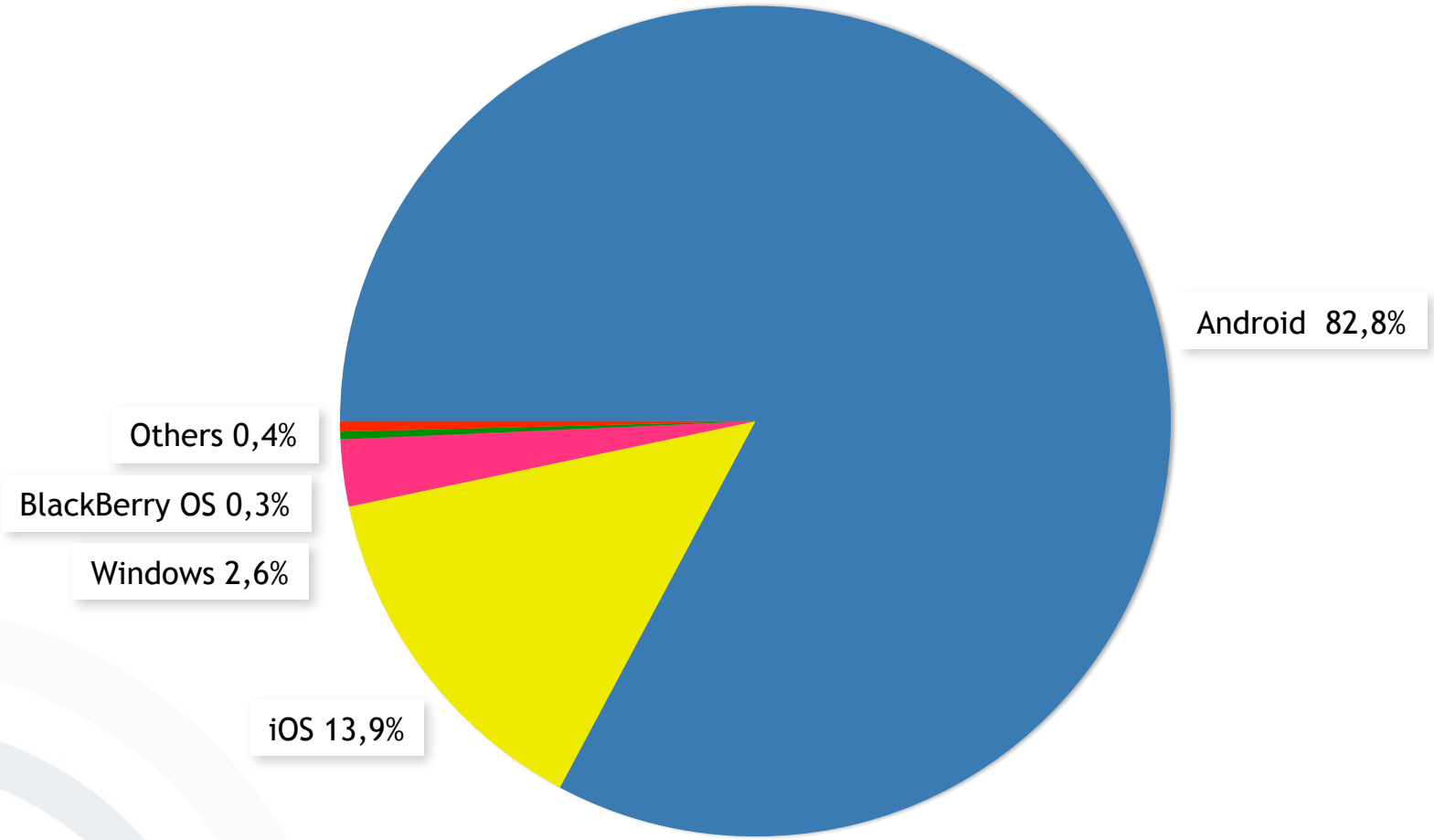
Worldwide smartphone sales to end users by operating system (Q2 2015)



[Statista 2015a]

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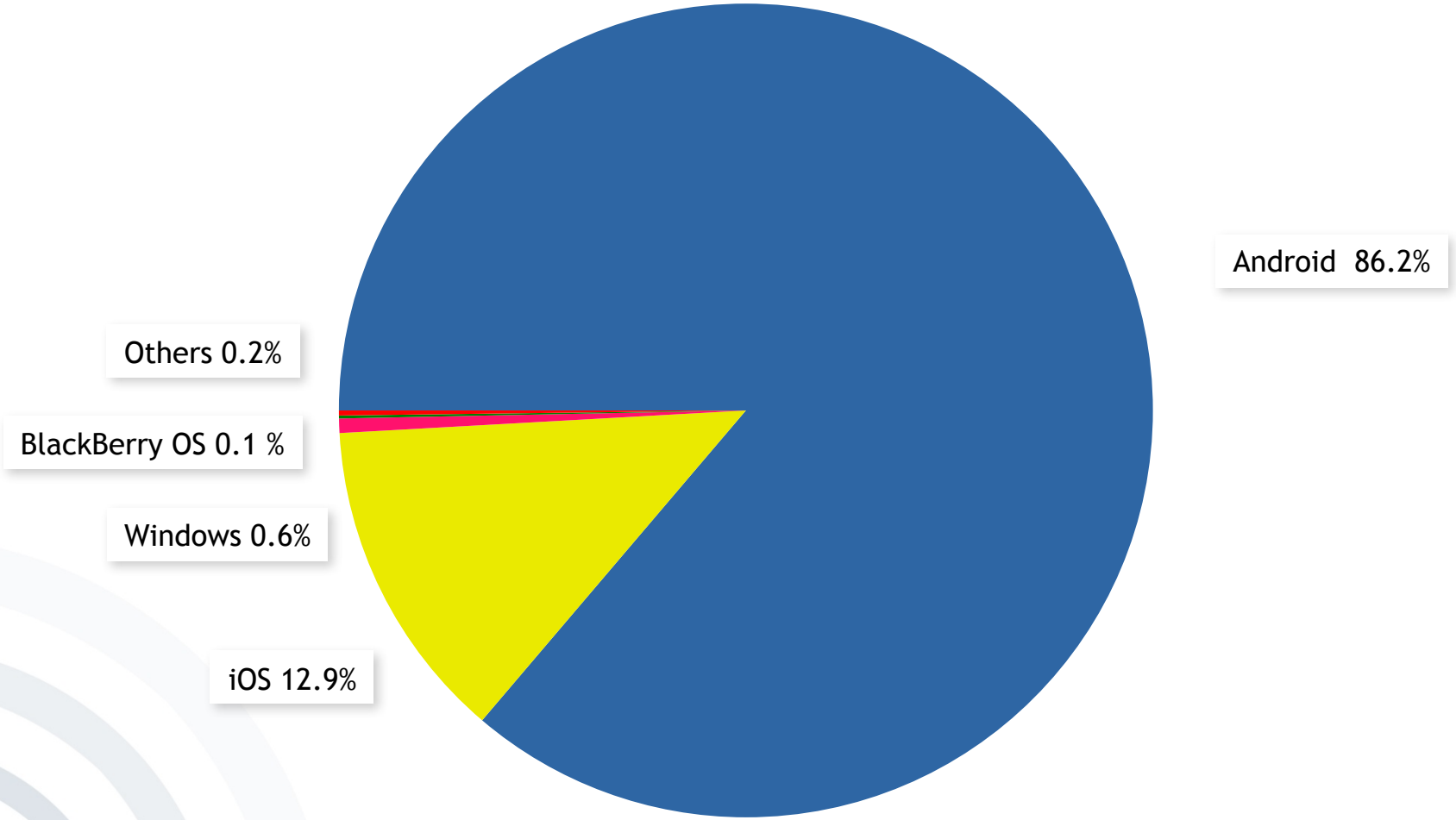
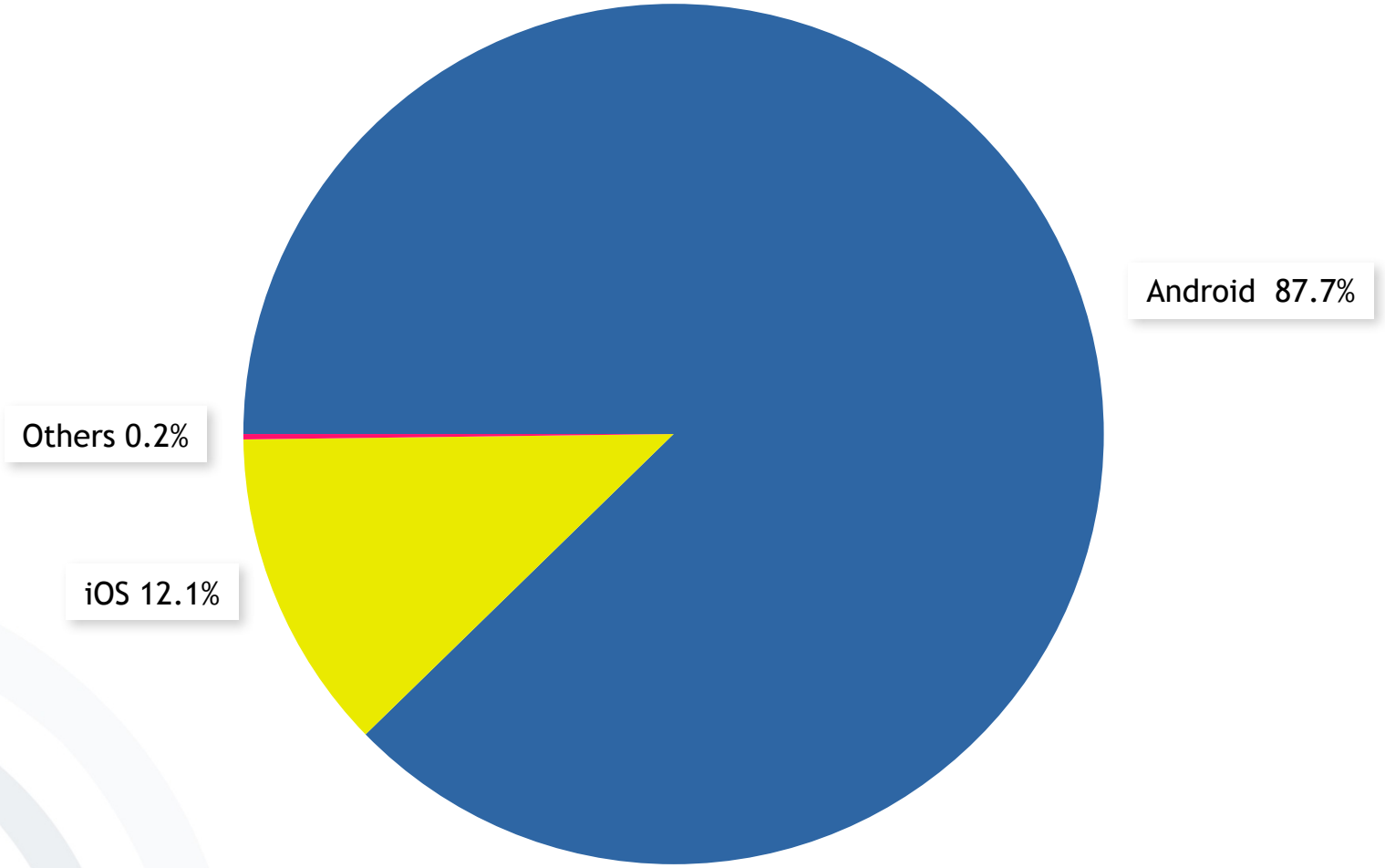
Worldwide smartphone sales to end users by operating system (Q2 2016)



[Statista 2016b]

Worldwide smartphone sales to end users by operating system (Q2 2017)



[Statista 2017]

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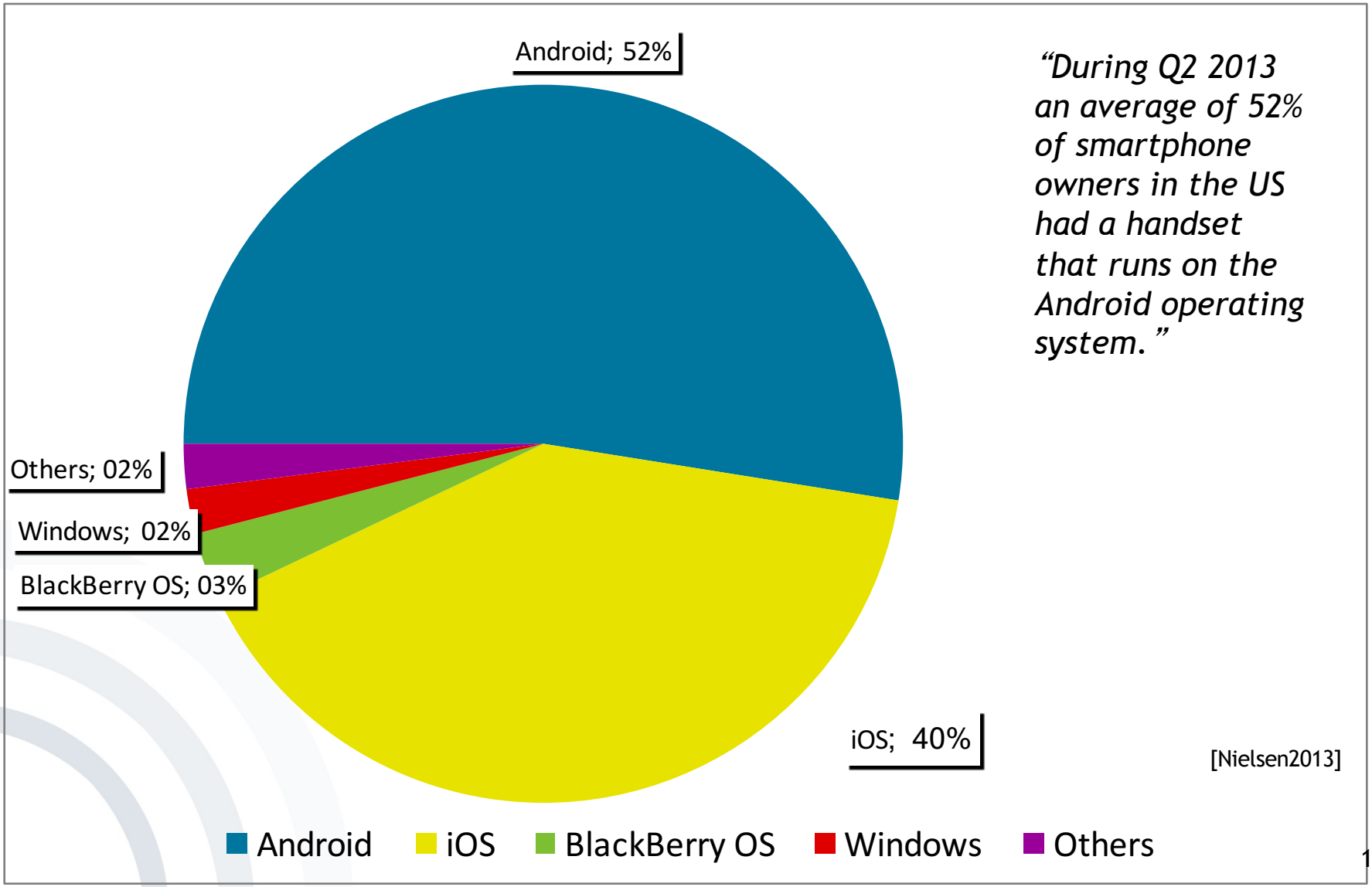
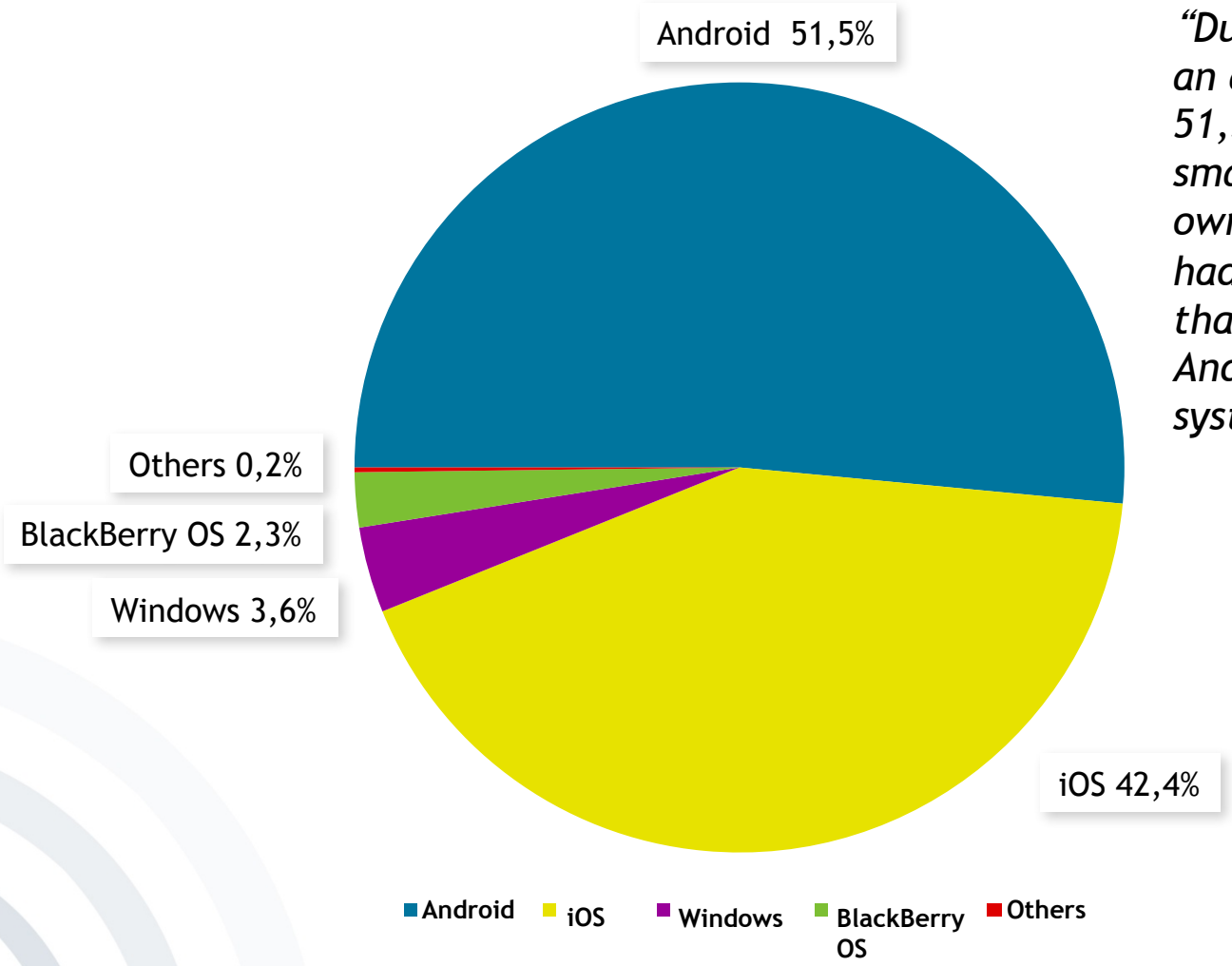
US installed smart phone base by operating system(Q2 2013)



"During Q2 2013 an average of 52% of smartphone owners in the US had a handset that runs on the Android operating system."

[Nielsen2013]

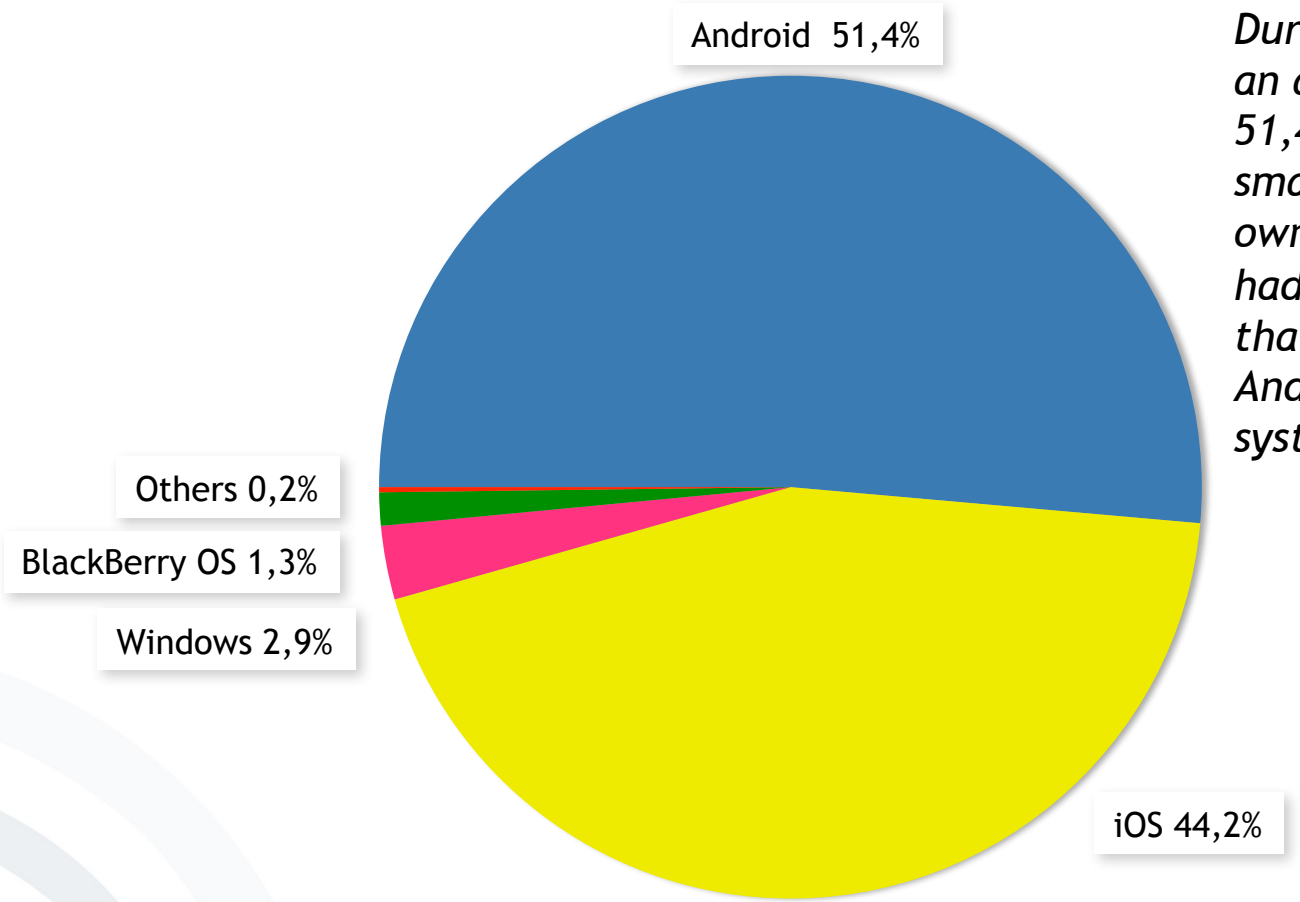
US installed smart phone base by operating system (July 2014)



"During July 2014 an average of 51,5% of smartphone owners in the US had a handset that runs on the Android operating system."

[Statista2014b]

US installed smart phone base by operating system (July 2015)



During July 2015 an average of 51,4% of smartphone owners in the US had a handset that runs on the Android operating system.

[statista2015a]

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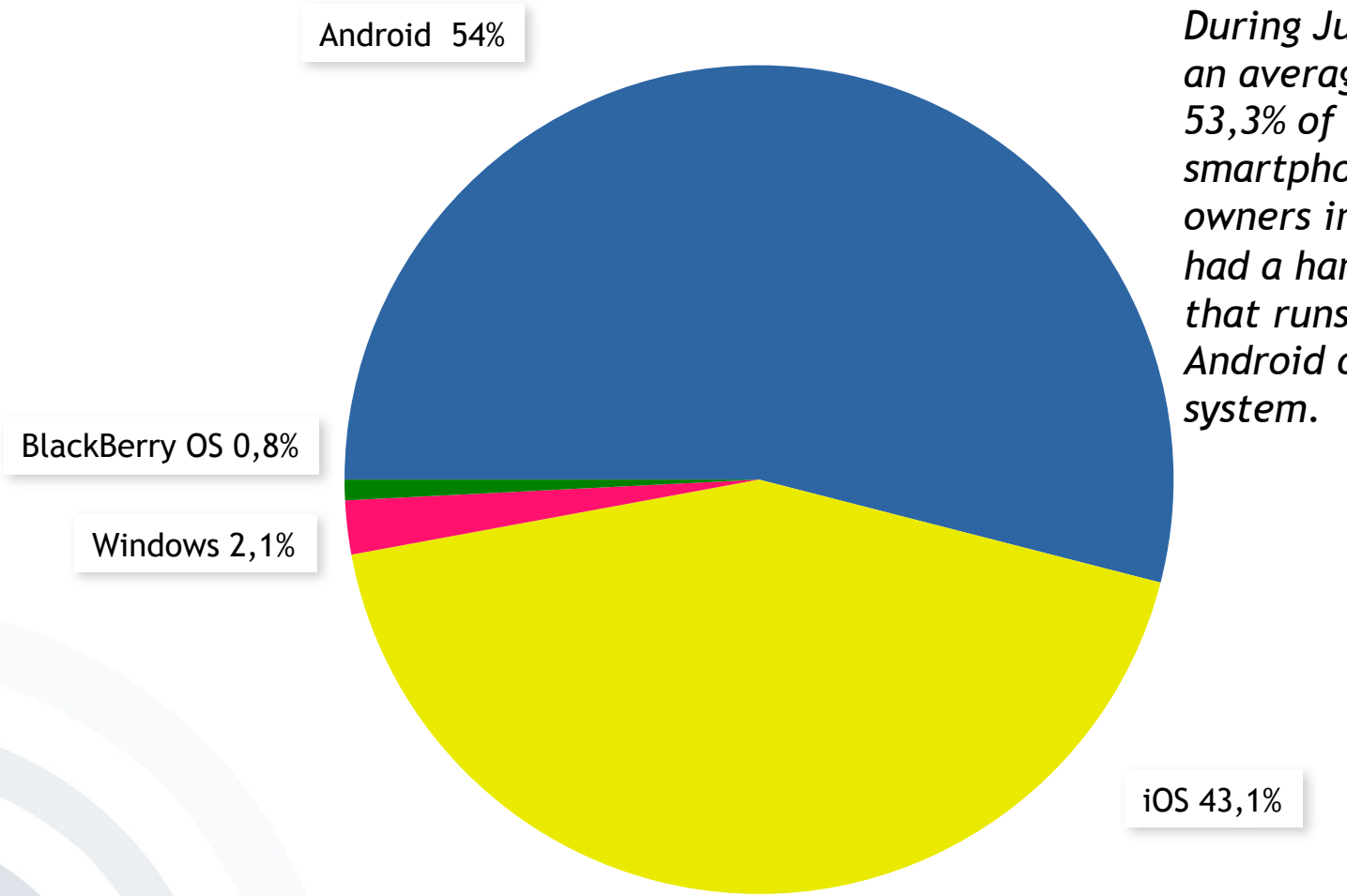
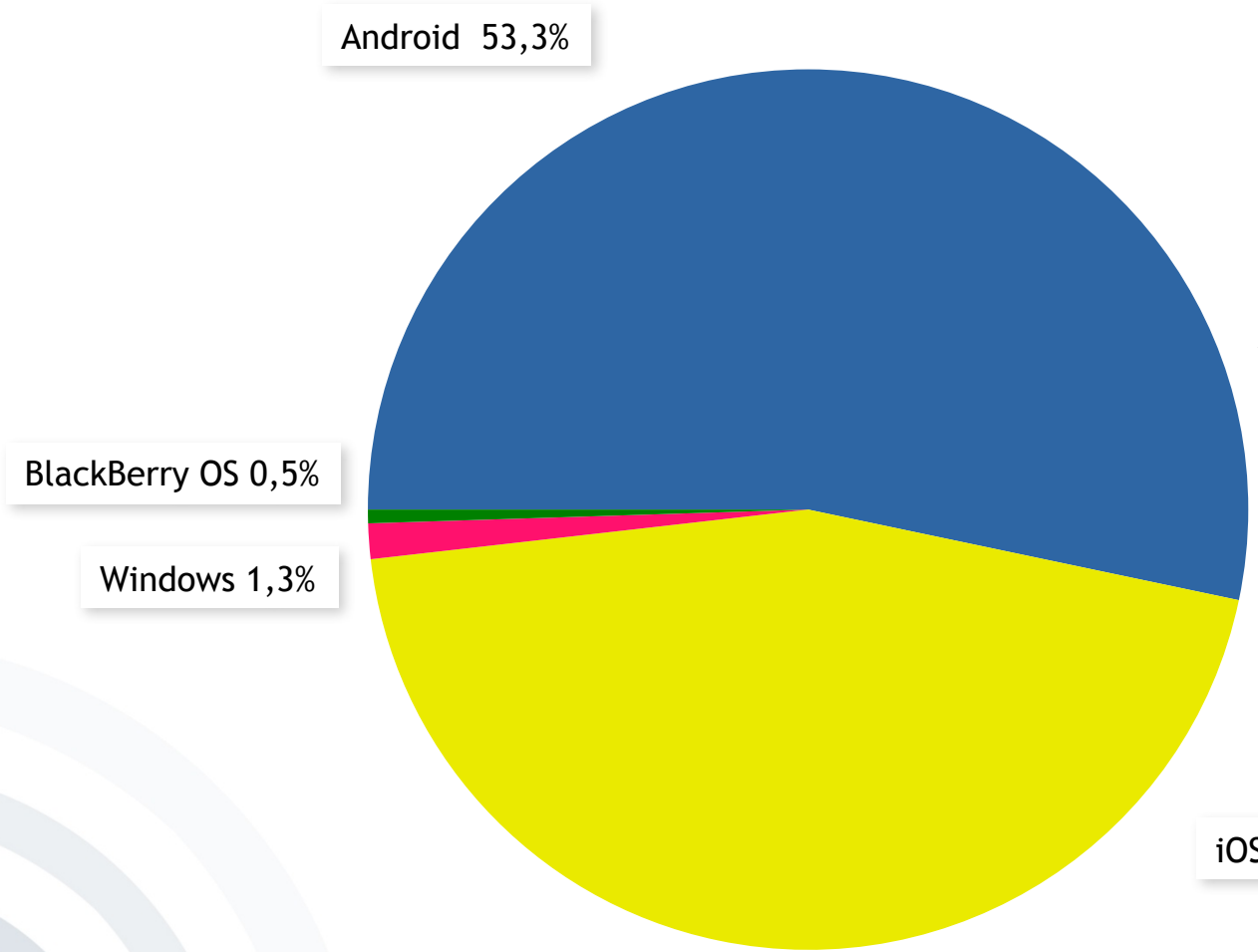
US installed smart phone base by operating system (July 2016)



During July 2016 an average of 53,3% of smartphone owners in the US had a handset that runs on the Android operating system.

[statista2016c]

US installed smart phone base by operating system (June 2017)



During June 2017 an average of 54% of smartphone owners in the US had a handset that runs on the Android operating system.

[statista2017b]

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Worldwide smartphone sales to end users by operating system Q2-2016 vs. Q2-2015 vs. Q2-2014

In 1.000 Units

Operating System	2Q16 Units	2Q16 Market Share (%)	2Q15 Units	2Q15 Market Share (%)	2Q14 Units	2Q14 Market Share (%)
Android	296,912.8	***86.2***	271,010	***82.2***	243,484	***83.8***
iOS	44,395.0	***12.9***	48,086	***14.6***	35,345	***12.2***
Windows	1,971.0	***0.6***	8,198	***2.5***	8,095	***2.8***
BlackBerry OS	400.4	***0.1***	1,153	***0.3***	2,044	***0.7***
Others	680.6	***0.2***	1,229.0	***0.4***	1,416.8	***0.5***
TOTAL	**344,359.7**	100.0	**329,676.4**	**100.0**	**290,384.4**	**100.0**

[Gartner2015, Gartner2016]

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Worldwide smartphone sales to end users by vendor Q2-2017 vs. Q2-2016 vs. Q2-2015

In 1.000 Units

Company	2Q17 Units	2Q17 Market Share (%)	2Q16	2Q16 Market Share (%)	2Q15	2Q15 Market Share (%)
Samsung	82,535.1	**22.5**	76,743.5	**22.3**	72,072.5	***21.9***
Apple	44,314.8	**12.1**	44,395.0	**12.9**	48,085.5	***14.6***
Huawei	35,964.3	**9.8**	30.670.7	**8.9**	25,825.8	***7.8***
Lenovo*	Others		Others		16,405.9	***5.0***
OPPO	26,092.5	**7.1**	18,489.6	**5.4**	Others	
Others	177,327.7	**48.4**	174,061.0	**50.5**	167,286.6	***50.8***
TOTAL	**366,234.4**	**100.0**	**344,359.7**	**100.0**	**329,676.4**	**100.0**

[Gartner2015,Gartner2016]

Long term trends (maybe?)

- Big players (originally from neighbouring fields) often have some (sometimes relatively modest) market share due to high investment:
  - Microsoft: Architectures, operating systems
  - Nokia: Feature phones
- Killer Application Champions are very successful for some time until their killer application is also available from the big players:
  - Palm: 1st small and affordable PDA with address book, calendar, and PC connectivity
  - RIM Blackberry: 1st PDA phone with push email

Mobile devices vs. stationary devices

- Due to the limitations of the mobile devices, mobile operating systems also have to cope with the following challenges:
  - Limited device capabilities and resources (storage, memory, processing time, etc.)
  - Usability issues
  - Security and system integrity issues

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- Attacks and countermeasures

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 in February 2004*

- Apple *iOS* (Unix-based)
  - Latest release: iOS 13.0

- *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 Cortado
  - 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)

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Mobile OS unavailable to other device manufacturers

General observations

- ***Advantage:*** Tend to be not as much affected by malware compared to operating systems available to many external manufacturers
- ***Disadvantage***: Less flexible, as 3rd-party software cannot be easily installed and executed
- Later, more and more platforms switched to more open and interoperable operating systems (e.g. Windows CE, Symbian OS, Android).

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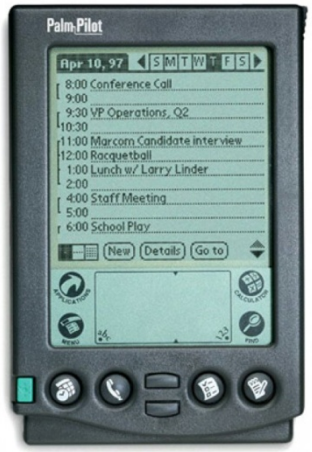
Palm OS
Devices



palm

palmsource
An ACCESS Company

Palm OS
Overview

- The operating system is made by *palmsource*
- Several device manufacturers:
  - Palm (e.g. Treo series)
  - Handspring
  - Garmin (navigation devices)
  - Fossil
  - Samsung
  - Sony
  - …
- Last version 6.1 (Cobalt) - 2004
  - There are no devices using version 6.1 on the market. Most of the devices are equipped with Palm OS 5.4 (Garnet), such as the Tungsten series.

Palm OS
Features

- Communication:
  - IrDA
  - Bluetooth
  - WiFi (IEEE 802.11)
  - GSM/GPRS
  - CDMA
- Support of the TCP/IP network protocol
- Integrated personal information management (PIM)
- Support for several encryption and security algorithms (e.g. RSA, SHA1, RC4)
- Large choice of 3rd party software available
- Long battery life

Palm OS
History

- 1996: Palm Pilot 1000, first device using Palm OS
- 1998: Palm III using Palm OS v3
- 2000: Palm IIIc, first device using Palm OS and a colour display
- 2003: Palm OS 5
- 2004: Palm OS 6.1 (Cobalt) and Palm OS 5.4 (Garnet)
- 2006: Palm's "*Treo Smartphones*" with Windows Mobile
- Name change to Garnet OS – future versions to be based on the Access Linux platform
- 2010: Hewlett-Packard acquired Palm for $1,2 billion, name change to HPwebOS
- 2011: HP announced to stop the production of all HPwebOS devices, including smart phones and tablets

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Apple iOS

- Developed by Apple for iPhone, iPod Touch, iPad and Apple TV
- Latest release: iOS 13
- iOS derived from Mac OS X, a Unix-based operating system
- Apple does not permit the OS to run on third-party hardware

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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

symbian OS

- Android (by Open Handset Alliance) 
  - Latest release: 10.0
- Windows Mobile
  - Latest release: Windows 10 Mobile 1703 (10.0.15063.608)

Windows 10

Windows Phone

- Windows Phone
  - Latest release: Windows Phone 8.1

MeeGo

maemo.org

- Maemo (by Nokia) → MeeGo (by Nokia, Intel) → Sailfish OS (by Jolla)
  - Latest release: Sailfish OS 2.1.0.1 (Iijoki) (April 2017)

TIZEN

- Tizen (by Samsung, Intel, Linux Foundation) 
  - Latest release: 3.0 (May 2017)
- Firefox OS (by non-profit organisation Mozilla) 
  - Latest release: 2.2.0 (April 2015)
  - Cancelled in September 2016

Firefox OS

KaiOS

- KaiOS (by Boot to Gecko) 
  - Latest release: 2.6.0 (May 2019)

 = Linux-based

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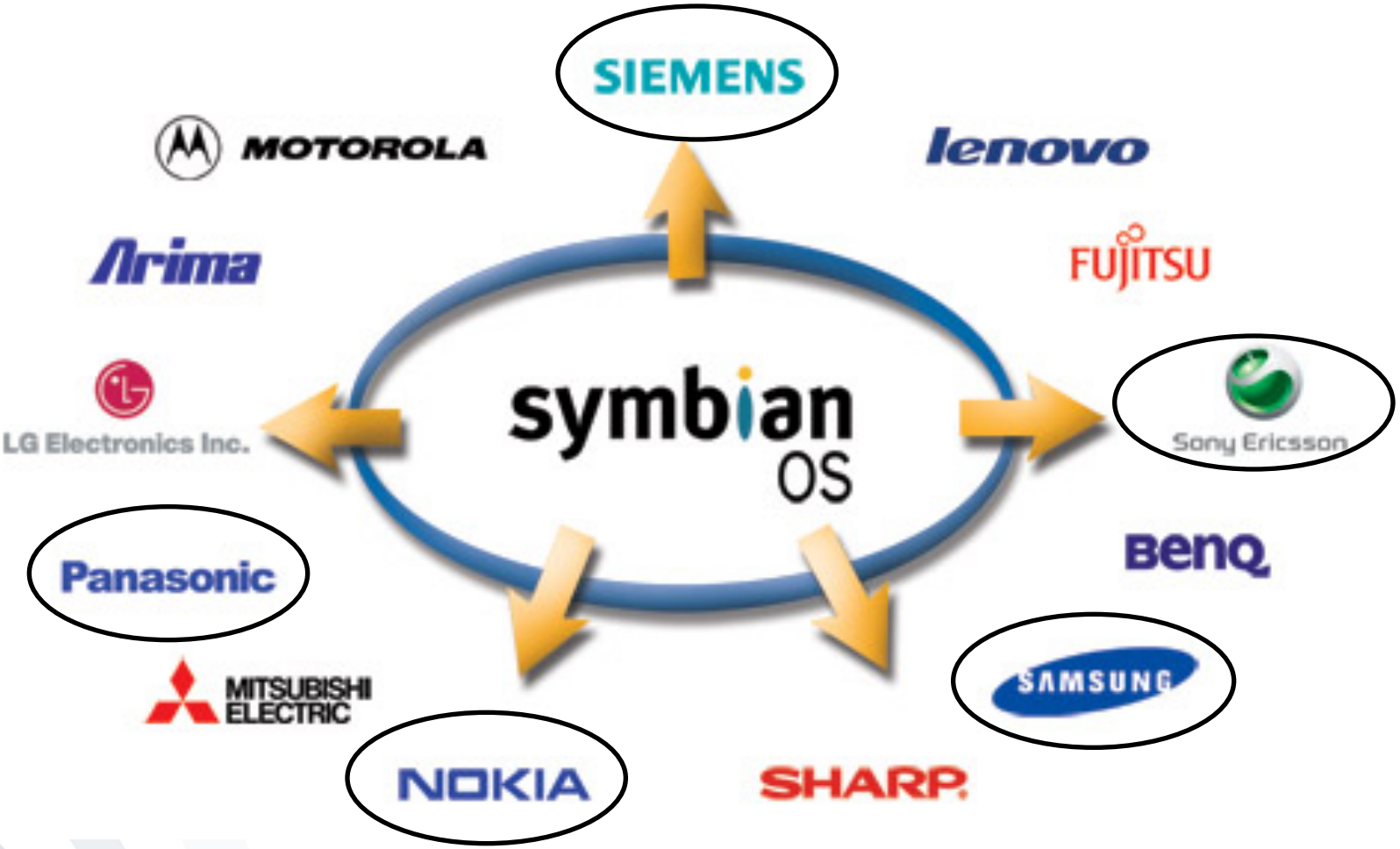
Symbian Devices

symbian

Symbian OS - the mobile operating system

Symbian Consortium/Licensees



In 2006, Symbian was owned by

[Symbian2006]

Symbian History 1998-2008

- Symbian was founded as a privately owned company in June 1998.
- Owner: Ericsson, Nokia, Panasonic, Psion, Samsung Electronics, Siemens and Sony Ericsson
- „Open“ Symbian OS telephones were available since 2001
  - „Open“: It is possible to install 3rd-party applications.
  - Beginning of 2001: Nokia 9210 Communicator
- 2004: Symbian OS 8.0
- 2005: Symbian OS 9.1 (S60 3rd edition)
- 2006: Symbian OS 9.3 released, extending the OS with WiFi and HSDPA
- 2007: Symbian OS 9.4 (S60 5th edition) = Symbian^1 („Symbian One“)
- 2008 June: **Symbian Foundation** announced
- 2008 December: **Nokia** buys Symbian Ltd. and becomes the **major contributor** to code of Symbian platform

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Symbian History 2009-2014

- 2009: **Symbian Foundation** founded
  Symbian platform successor to Symbian OS and Nokia Series 60.
- 2010: Symbian OS 9.5 (Symbian^3). Nokia N8 first smartphone to run Symbian^3.
- 2010 November: Due to a lack of support from funding members, **Symbian Foundation transition into a licensing-only organisation**. Nokia takes over governance of the Symbian platform.
- 2011: Symbian Anna and Symbian Belle as an update to Symbian^3
- 2011 February: Nokia collaborates with Microsoft and adopts Windows Phone 7 for their smartphones. **Relevance of Symbian platform, especially in the mobile app market, drops significantly**. Market share in sharp decline, notably in the high priced smartphone segment
- 2011 September: Nokia **outsources** Symbian software development and 2,300 employees to Accenture
- 2012: Symbian Belle renamed to Nokia Belle
- 2013: Nokia Belle Feature Pack 2 (latest version)
- 2014 January: No new applications can be published in the Nokia Store (store.ovi.com) [Nokia2013]

- 2015 January: Nokia Store discontinued and partially transferred to Opera Mobile Store.

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Embedded Linux
Devices

Embedded Linux
Overview

- Linux is an „*Open Source*“ operating system.
- Only a limited amount of device manufacturers were offering devices with a pre-installed Linux solution (e.g. Motorola, NEC, Panasonic).
- However, there are several Linux distributions, such as µCLinux, that can be installed on existing devices (e.g. iPAQ).
- Motorola, as one of the major mobile phone manufacturers, was using Linux as (one) of their OS platforms.

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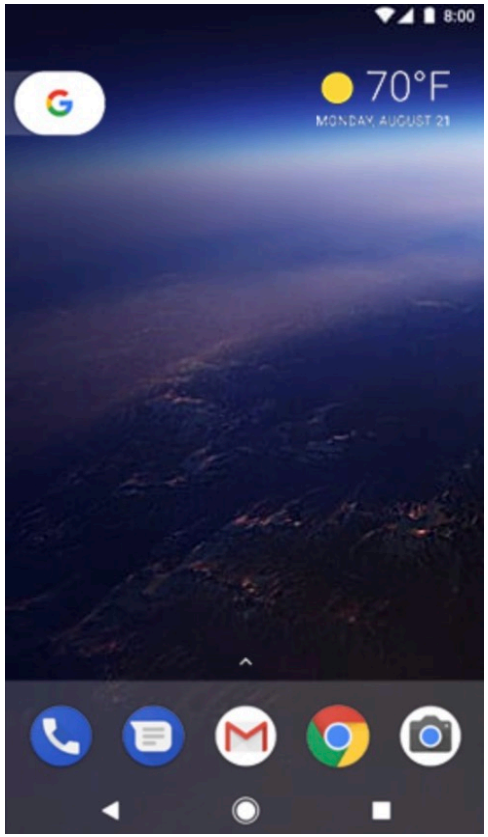
Android

- Google and other members of the **Open Handset Alliance** collaborated to develop and release Android.
- Open Handset Alliance (OHA) established in 2007
- Android based on modified version of Linux kernel
- October 2008: First commercially available phone running Android: T-Mobile G1
- September 2019: Version 10.0



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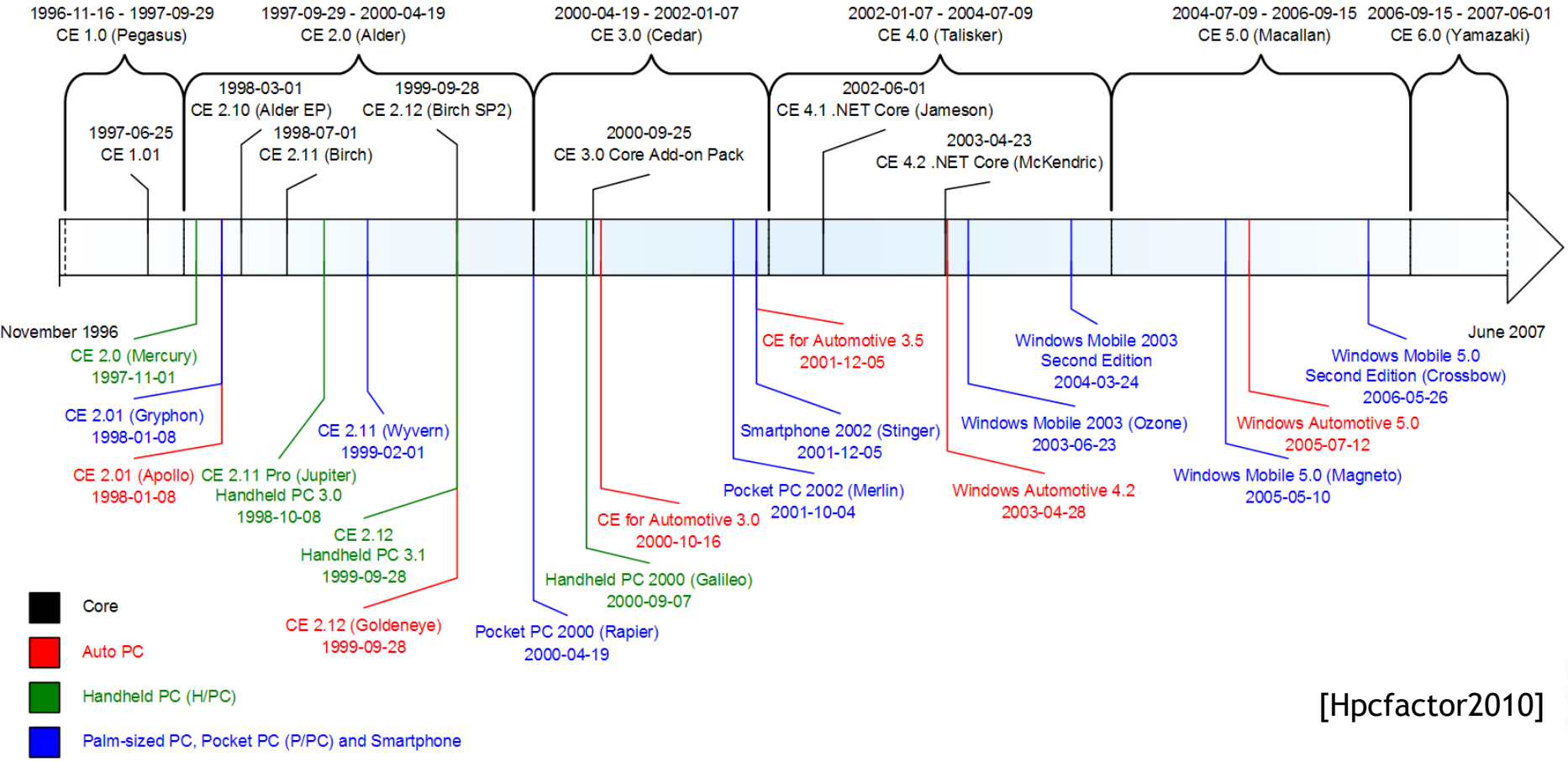
Windows CE, Pocket PC, Pocket PC Phone Edition, Mobile Devices

All screens are simulated.

Windows CE, Pocket PC, Pocket PC Phone Edition, Mobile History

Windows CE Timeline

Source: "A Brief History of Windows CE" (http://www.hpcfactor.com/support/windowsce/), *HPC:Factor*, retrieved May 21, 2007



[Hpcfactor2010]

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Microsoft Windows Phone 7

Windows Phone

- Launched in October and November 2010
- Successor to Windows Mobile platform, but **technically a new and different platform without backward compatibility**
- Aimed at consumer market instead of enterprise market unlike Windows Mobile
- New user interface

Microsoft Windows Phone 8

Windows Phone

- Windows Phone 8 launched in October 2012 together with Windows 8 with similar optics
- Successor to Windows Phone 7
- Latest release: Windows Phone 8.1 in April 2014

Microsoft Windows 10 Mobile

- Windows 10 Mobile Insider Preview available in July 2015.
- November 2015: Supported phones include HTC One (M8) and 36 Lumia models.
- Other eligible Windows Phone devices can receive updates since March 2016.

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Firefox OS

- Linux-based open-source mobile OS for smartphones and tablet computers
- Originally developed by **Mozilla**, a non-profit organization known for the Firefox web browser
- Focus on open standards, e.g. HTML5 applications
- 2012-02: Firefox OS first publicly demonstrated
- 2013-07: First commercial Firefox OS based phones launched:
  - *ZTE Open* in Spain by Telefónica
  - *Alcatel One Touch Fire* in Poland by Deutsche Telekom (also sold in Germany by subsidiary *Congstar*)
  - *LG Fireweb* in Brazil by Telefónica brand *Vivo*
- Mozilla expressed strong position on **user privacy**
  - Upon installation of applications, a reason is stated why certain rights are necessary and need to be granted by the user.
  - User data will be analysed locally on the device, not transferred to servers, exploited or traded.
- 2015-12: Mozilla announced to stop offering smartphones through mobile operator channels.
  - Possible pick-up: H5OS by Acadine Technologies
- 2016-09: Mozilla work on Firefox OS ceased
- Latest release: 2.2.0 (2015-08)
- Latest developer version: 2.6.0 (2015-10)
- Forked to form KaiOS

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KaiOS

- A mobile OS based on Linux
- Owned by KaiOS Technologies, a US-based company
- Forked from B2G (Boot to Gecko), an open source community-driven successor of Firefox OS
- 2017: Initial release
- 2018: Google invested US $ 22 million in the OS. India-based telecom operator Reliance Jio also invested $ 7 million in cash to pick up a 16% stake.
- KaiOS beat Apple's iOS for second place in India, while Android dominates with 71%:
  - Largely attributed to popularity of the competitively-priced Jio Phone.
  - In Q1 2018, 23 million KaiOS devices were shipped in Asia, Africa, Middle East, Latin America, and North America.
- KaiOS supports:
  - 4G LTE E, VoLTE, GPS and Wi-Fi with HTML5-based apps.
  - A dedicated app marketplace called KaiStore enables users to download applications.
  - Lightweight hardware resource usage, and is able to run on devices with just 256 MB of memory.
- Latest release: 2.6.0 (2019-05)

Source: https://www.zdnet.com/product/nokia-8110-4g/

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  - Microsoft Windows CE, Pocket PC, Pocket PC Phone Edition, Mobile
  - Microsoft Windows Phone / 10 Mobile
  - Firefox OS
  - KaiOS
- Attacks and countermeasures

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)

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]

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Timeline mobile threats 2004-2016

[Sophos2016]

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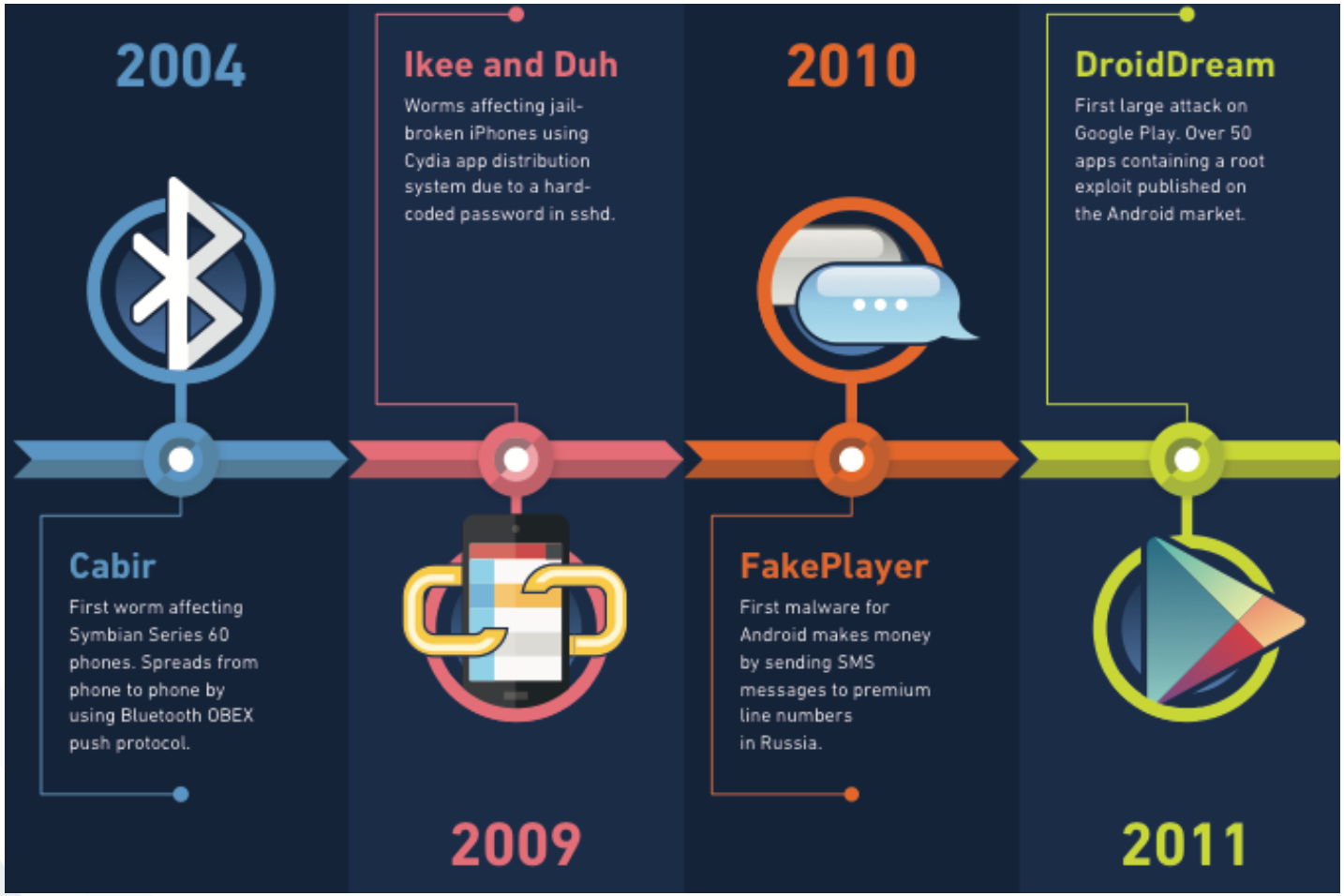
Timeline mobile threats 2004-2011



[Sophos2016]

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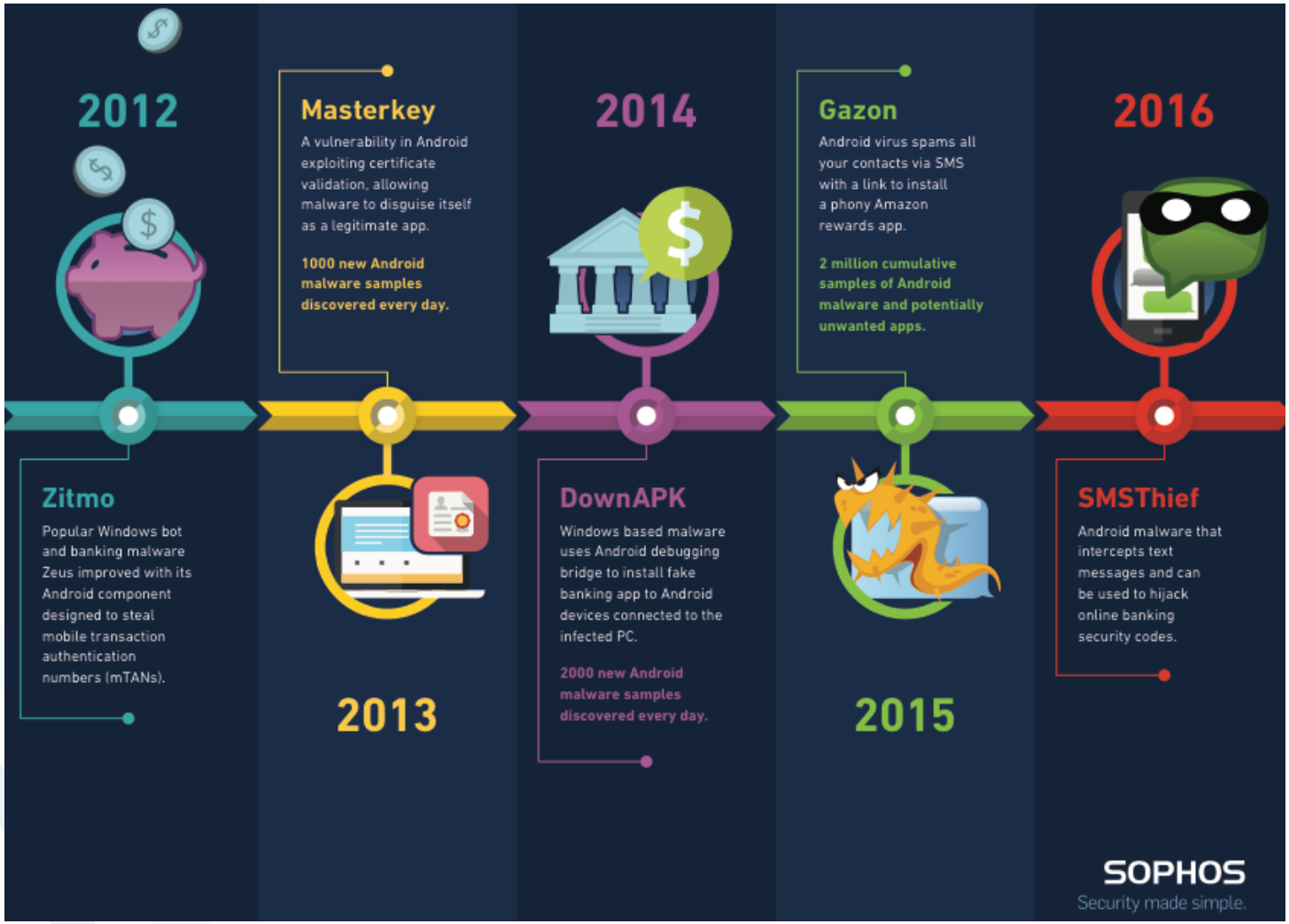
Timeline mobile threats 2012-2016

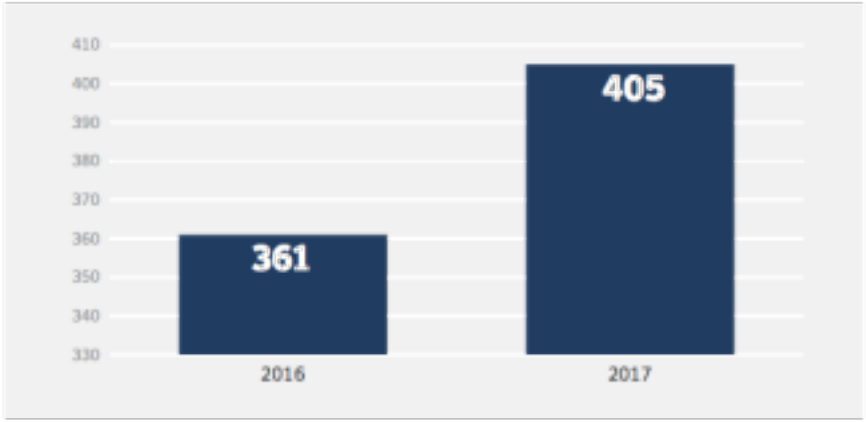


[Sophos2016]

Mobile threats in numbers

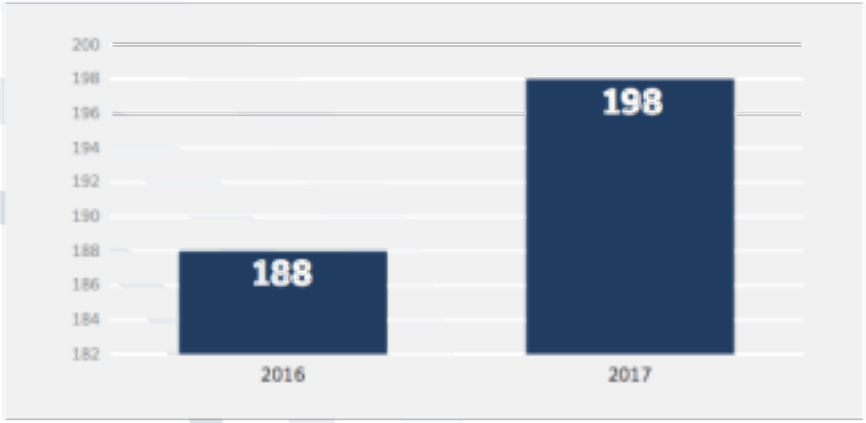
New mobile malware families

The number of new mobile malware families increased by 12.2 percent between 2016 and 2017.



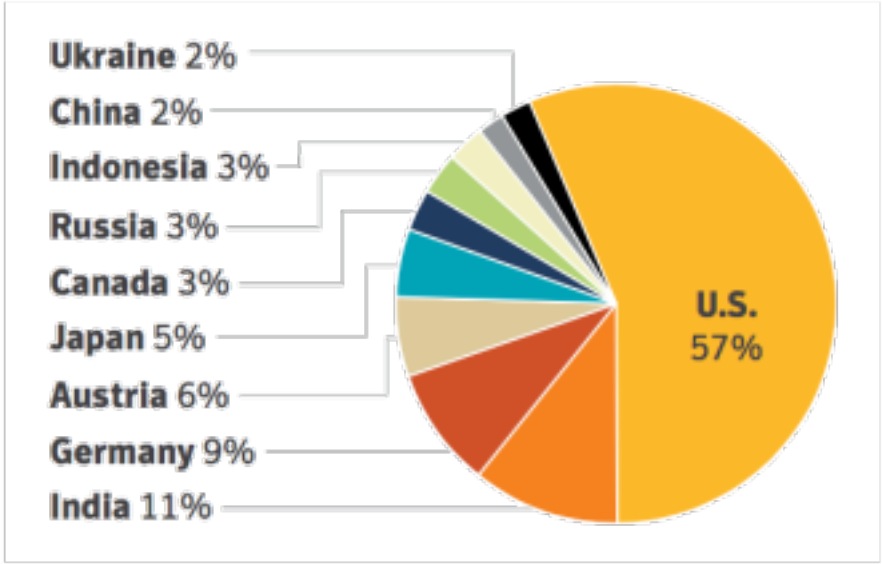
New mobile grayware families

The number of new mobile grayware families grew by 5.3 percent in 2017.



Top countries for mobile malware

Top 10 list of countries where mobile malware was most frequently blocked in 2017.



[Symantec2018]

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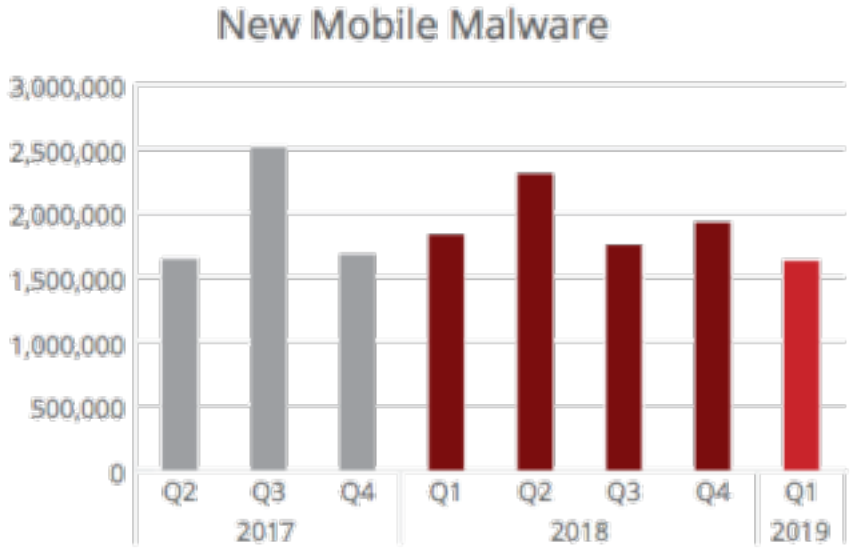
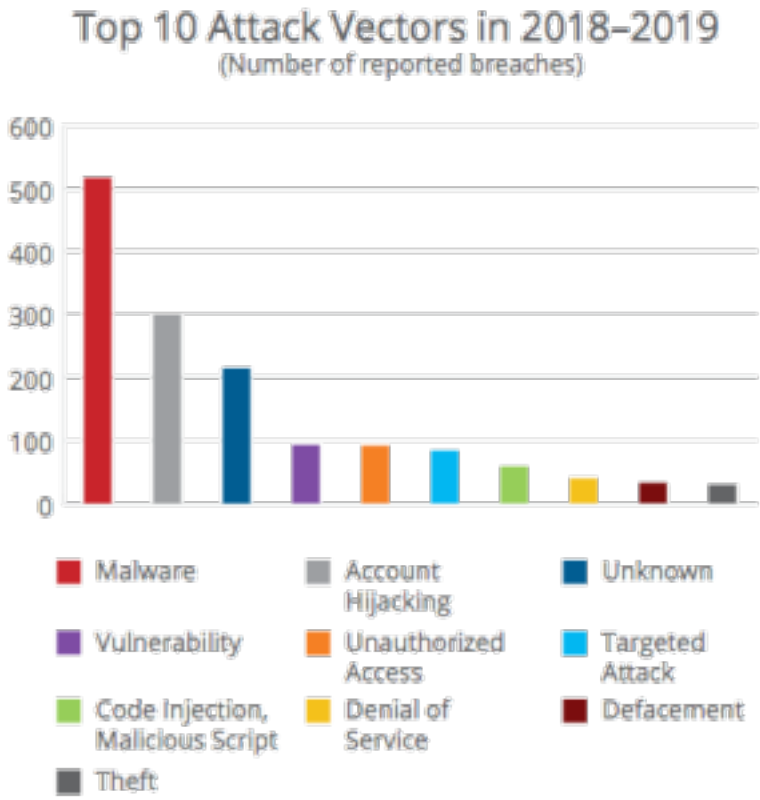
Mobile threats in numbers





[McAfee2019]

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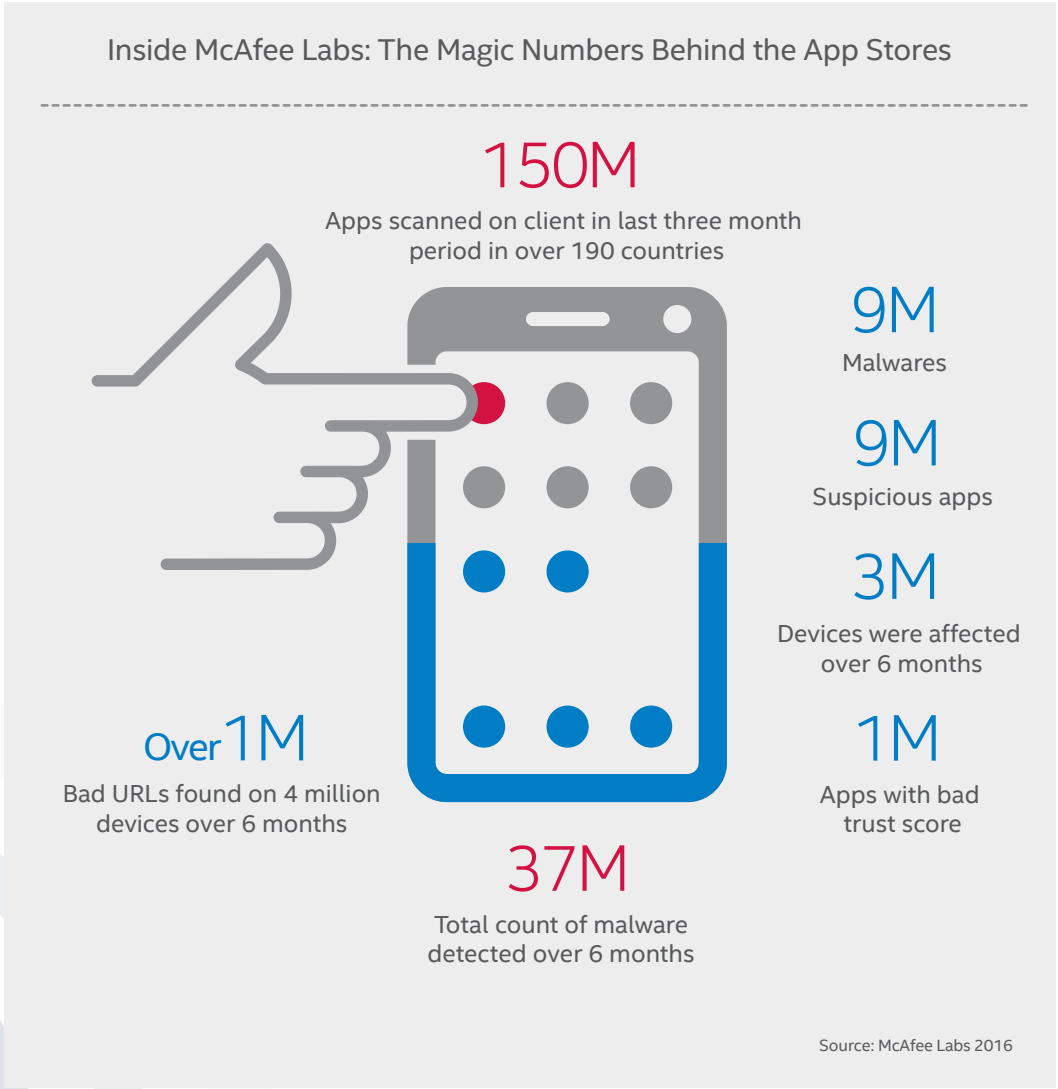
Further trends in the "attack landscape"

- Attacks are becoming commercial services for "customers" (e.g. distributed-denial-of-service).
- Mobile devices may get „recruited" for executing attacks.
- States attack mobile devices upfront (e.g. FBI vs. Apple).
- Apps and security softwares are major attack vectors.

Mobile threats within 6 months in 2015-2016



[McAfee2016]

Mobile threats

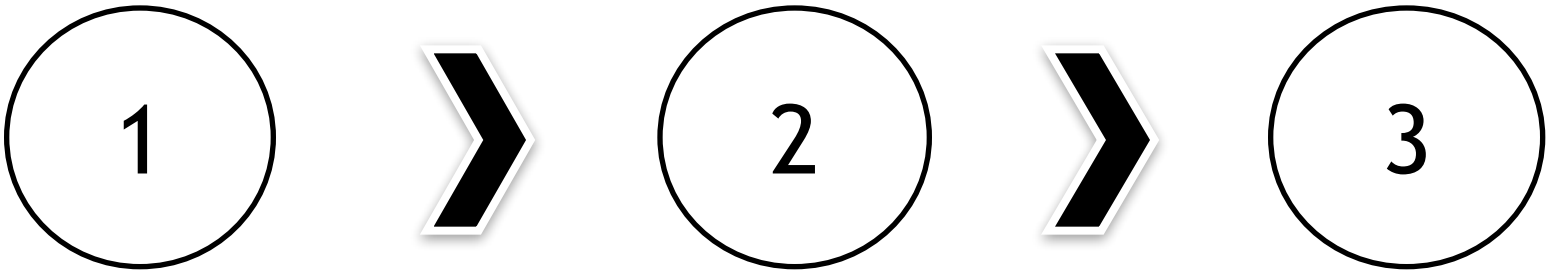
Real-World Examples

- A one-week behaviour analysis of top 10 Android fitness apps revealed:
  - They accessed sensitive data while users were not interacting with devices.
  - They transmitted sensitive data to remove servers without user's knowledge.
  - Transferring data to outside EU (GDPR issue).
  - Promises did not match actions (privacy policies Vs. real behaviour).

[Hatamian2019-1]

Countermeasures
Consumers' Perspective

- A3: Android App Behaviour Analyser



Responsible for monitoring apps' behaviour

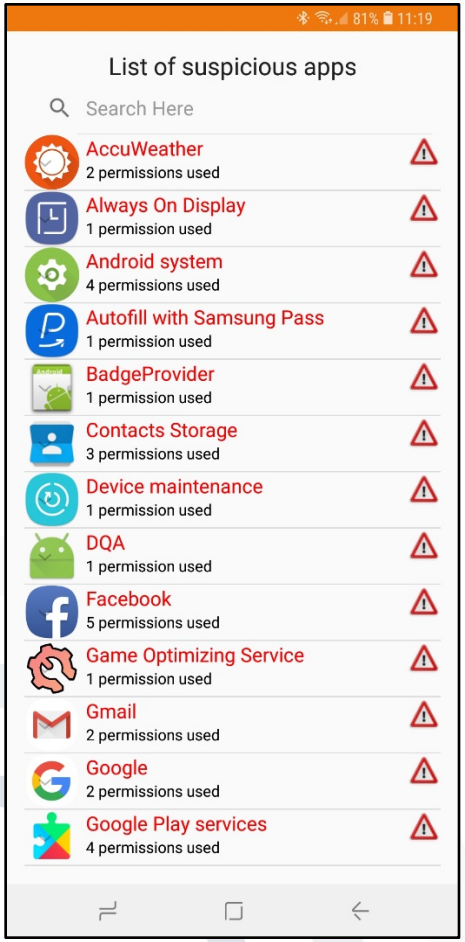
Analysing potential privacy risks

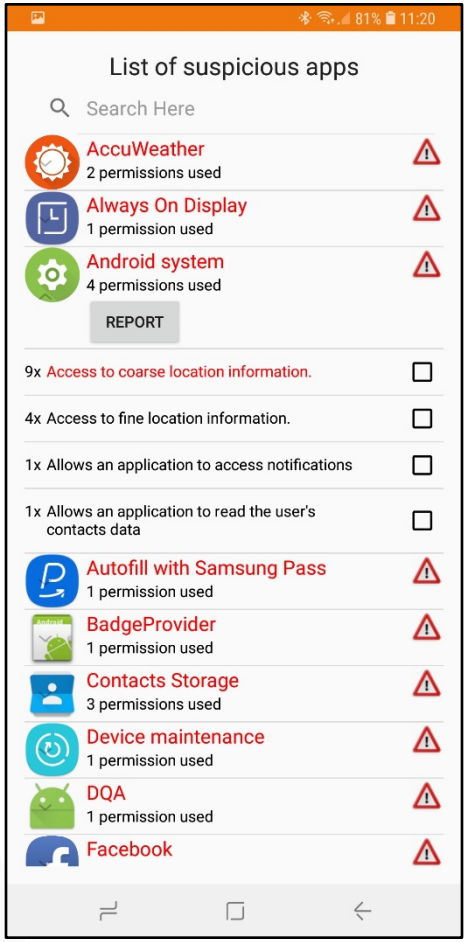
Risk communication to users

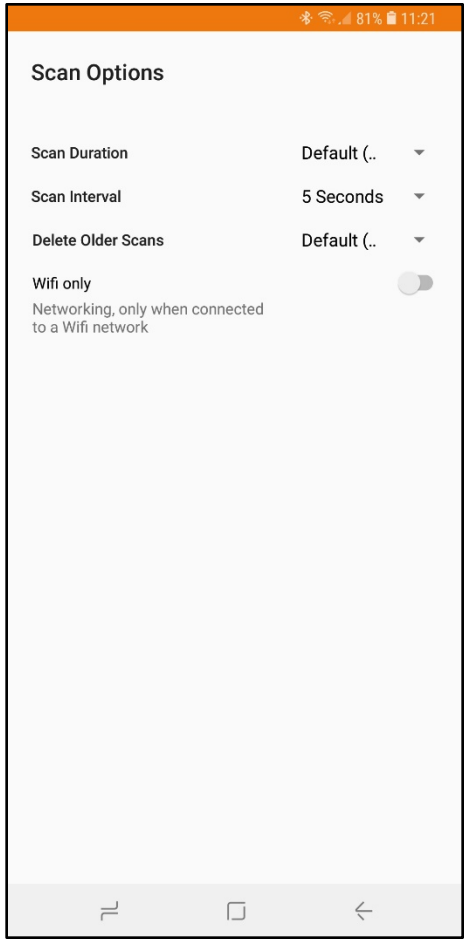
[Hatamian2017-2]

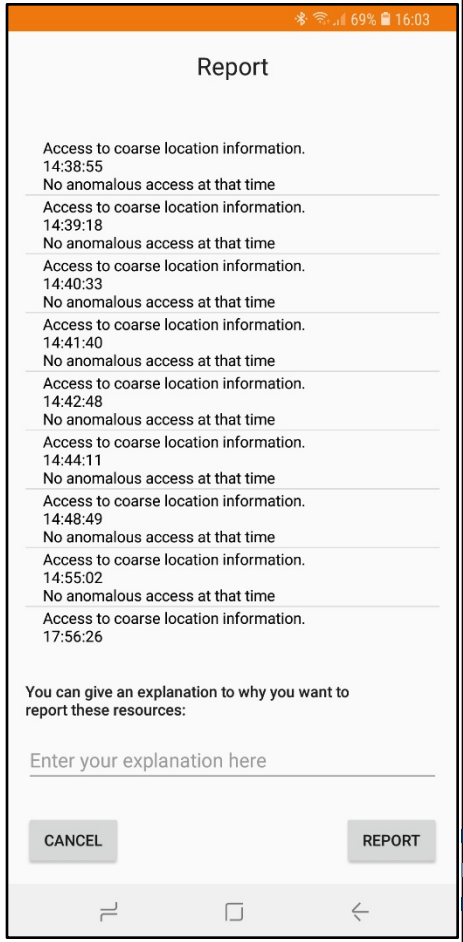
Countermeasures
Consumers' Perspective

- A3: Android App Behaviour Analyser





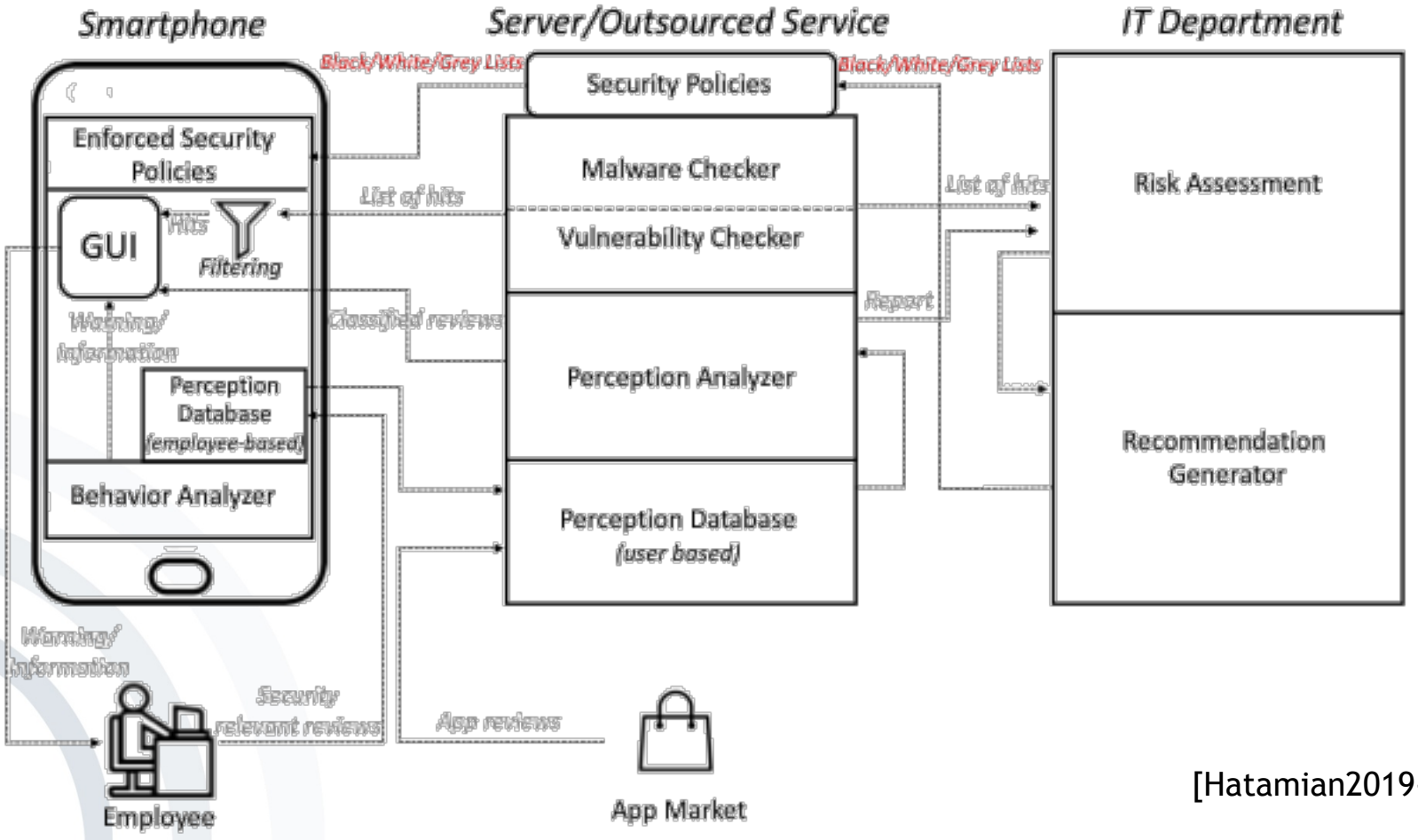




[Hatamian2017-2]

Countermeasures
Corporate's Perspective

- ESARA: A Framework for Enterprise Smartphone Apps Risk Assessment



[Hatamian2019-3]

Technical security precautions and measures

- 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 they are started by e.g.
  - Checking certificates
  - Proof Carrying Code
- Additional security software may be needed, e.g.
  - Virus scanners
  - Firewalls

Access control

- Every user has certain assigned access rights, e.g.
  - Reading a file
  - Writing a file
  - Accessing a peripheral device
- The OS controls that users or the processes started by a user, can only execute those actions, which they are allowed to.

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Access matrix

Object / User	File 1	File 2	File 3	Device's periphery
U1	Read		Read	
U2				Print
U3		Read	Execute	
U4	Read Write		Read Write	

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