



**COMPUTER SCIENCE**  
**CASE STUDY: SMARTPHONES**

For use in May 2012, November 2012, May 2013 and November 2013

---

**INSTRUCTIONS TO CANDIDATES**

- Case study booklet required for higher level paper 2 and standard level paper 2 computer science examinations.

## ***Contents***

INTRODUCTION . . . . .	3
CONVERGENCE OF TECHNOLOGIES . . . . .	3
FUNDAMENTALS . . . . .	4
COMMUNICATION . . . . .	5
BLUETOOTH . . . . .	5
OTHER COMMUNICATION TECHNOLOGIES . . . . .	6
INTERFACES . . . . .	7
KEYBOARD . . . . .	7
TOUCH SCREEN . . . . .	7
GENERATIONS . . . . .	8
SECURITY . . . . .	9
SMARTPHONE APPLICATIONS . . . . .	10
EFFECTS ON SOCIETY . . . . .	11
WELCOME TO THE FUTURE . . . . .	12
APPENDIX I – ABBREVIATIONS USED IN THE CASE STUDY . . . . .	13
APPENDIX II – ADDITIONAL TERMINOLOGY TO THE GUIDE . . . . .	13
APPENDIX III – BIBLIOGRAPHY . . . . .	14

*The IB respects the principles of intellectual property and makes strenuous efforts to identify and obtain permission before publication from rights holders of all copyright material it uses. It is grateful for permissions received for material used in this publication and will be pleased to correct any errors or omissions at the earliest opportunity.*

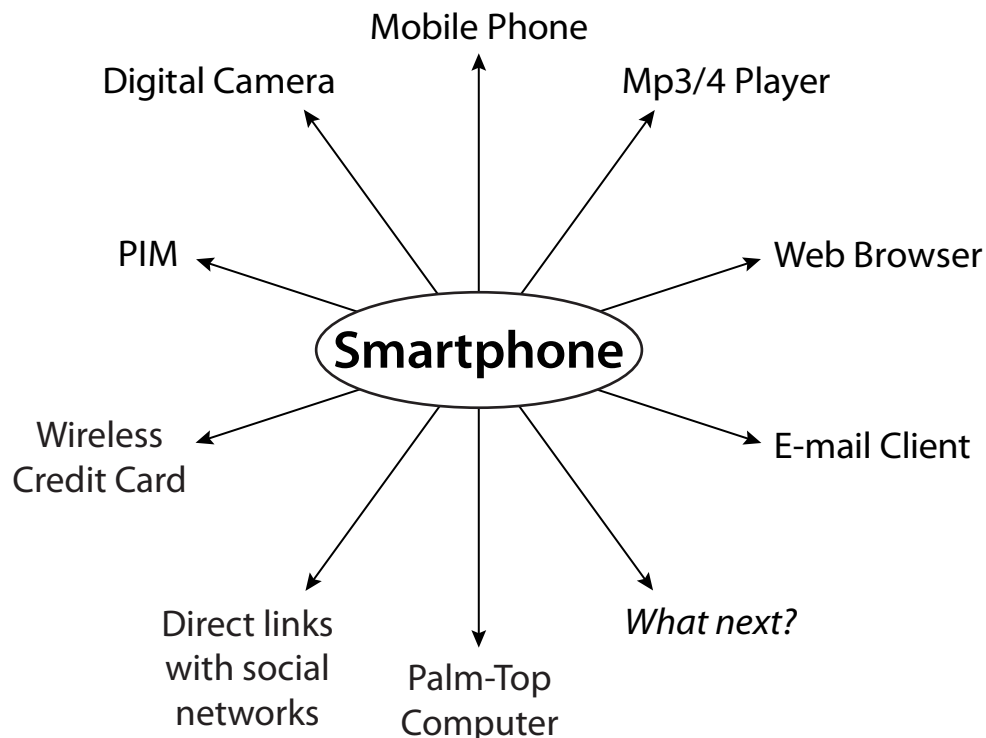
## ***Introduction***

This case study is intended to act as a **starting point for investigating** a number of topics related to the use of mobile devices. These include:

- the technology underpinning mobile devices
- the application and evolution of mobile devices in society
- social and ethical issues, such as security and privacy, relating to the use of mobile devices
- independent research linked to the additional terminology in this case study.

Mobile devices have become essential requirements for people living in the modern world. Whether it be for business men and women keeping track of appointments or for working on the move, teenagers keeping in (almost permanent) touch with friends or relaxing to music, or simply as a must-have fashion accessory, the mobile device in its various forms has become a prominent symbol of today's world. It is advances in technology coupled with our insatiable desire for communication that has driven the evolution from the early days of the palm top computer to today's smartphone and, no doubt, to more complex forms in the future.

## ***Convergence of Technologies***



## Fundamentals

### Memory

Mobile devices have the following types of memory built in:

- ROM (firmware)
- Cache Memory
- RAM
- Flash Memory.

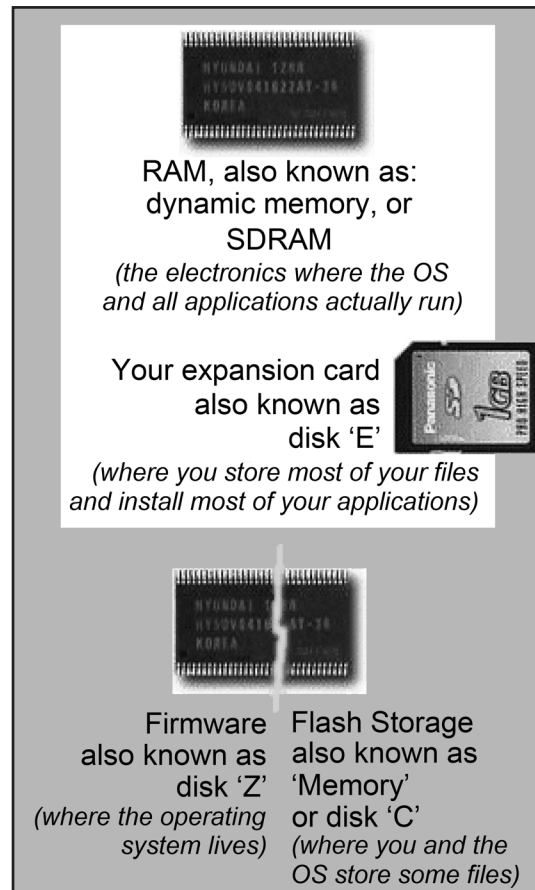
Additional memory is also provided for some devices through the use of memory cards.

### Operating Systems

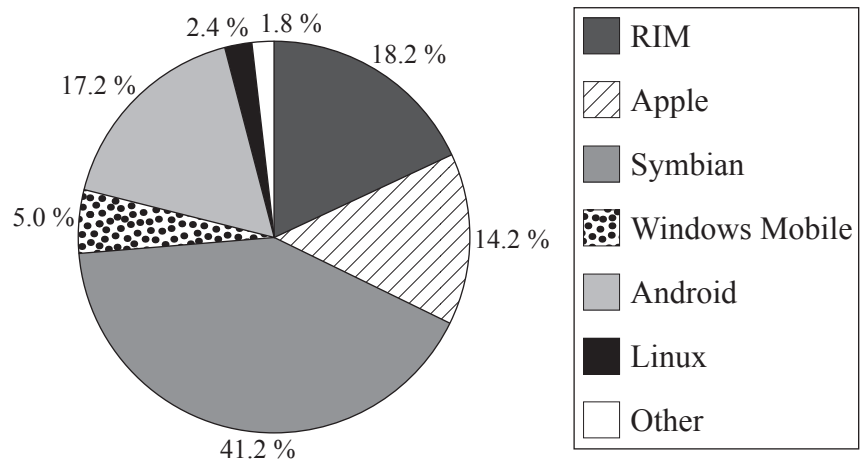
In comparison to the dominance that Microsoft experiences with computer operating systems (OS), there is no such dominance with mobile devices, as illustrated by the accompanying graph, which shows the share of sales in August 2010. The most popular OS is Symbian, which is an open-source development.

### Processor

The vast majority of mobile devices have processors based on the ARM family of 32-bit RISC architecture. One of the principle features of this architecture is very low power consumption. It was estimated that 90 % of all mobile phones operating in 2010 would incorporate this design.<sup>1</sup>



[Source: [www.allaboutsymbian.com/features/item/Keeping\\_It\\_Clean.php](http://www.allaboutsymbian.com/features/item/Keeping_It_Clean.php)]



[Source: adapted from [www.gartner.com/it/page.jsp?id=1421013](http://www.gartner.com/it/page.jsp?id=1421013)]

<sup>1</sup> [www.reuters.com/article/idUKTRE6111TA20100202](http://www.reuters.com/article/idUKTRE6111TA20100202)

## Communication

Mobile devices rely on their ability to communicate both with each other and with fixed devices such as personal computers. At times this communication is direct, but at other times a mobile phone (cell phone) network is used. There are various methods of communication, each with its own protocol, and each providing certain advantages and disadvantages when compared with one another.

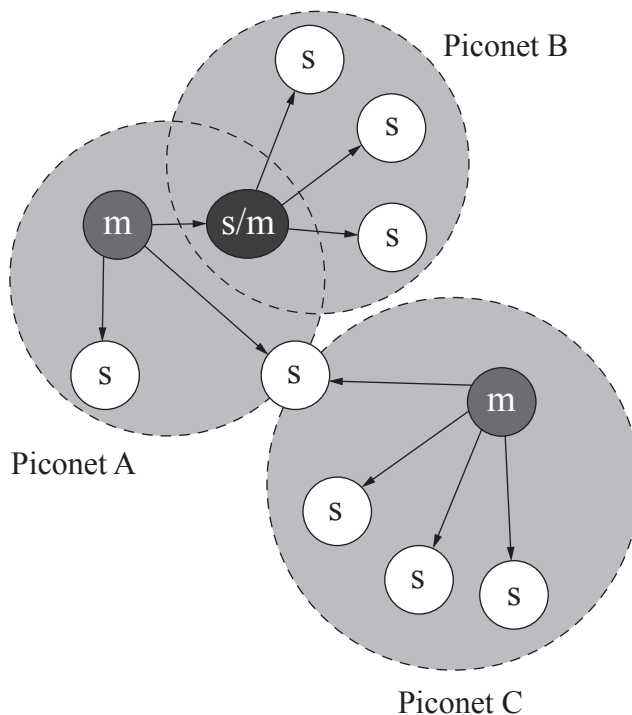
### Bluetooth<sup>2</sup>

A common means of communication is Bluetooth, which uses radio waves in the frequency band 2.402 GHz – 2.480 GHz to allow Bluetooth enabled devices to automatically connect with each other. Once a connection is made, data can be transferred in either direction, although this will depend upon the security mode selected for each device. One important use for this is the *synchronization* of data between two devices.

The power consumed in communicating is very low and consequently the range is limited. However, signals can pass through the walls of a building as line-of-sight is not required.

When a connection is made between two or more devices a *piconet* (personal area network) is formed. Several piconets can exist within the same area without interfering with each other. This is achieved both by *frequency hopping* and by the use of device addresses.

An example of multiple piconets is shown below.



- temporary network
- up to 8 active devices (as of 2010)
- master (m) controls the piconet and the slaves (s)
- each Bluetooth device can act as both a slave in one piconet and a master in another

[Source: <http://developers.sun.com/mobility/midp/articles/bluetooth1>]

The number of devices that incorporate Bluetooth has increased dramatically since its conception, as are the uses to which they are put. These include the use of Bluetooth headsets and Bluetooth enabled GPS devices.

<sup>2</sup> <http://electronics.howstuffworks.com/bluetooth2.htm>

### **Other Communication Technologies**

In addition to Bluetooth there are other means of communication between mobile devices, each having their own advantages and disadvantages. These include the following:

- Wi-Fi
- Mobile Phone (Cell Phone) Networks
- Infra-Red
- USB
- Ethernet
- WiMAX
- Firewire.

## Interfaces

People will not pay for complex technology if they are unable to use it. The means of interacting with their mobile device has become as important a factor in buying it as the functions that it actually carries out. Consequently, companies have devoted considerable time and money into researching ways of providing easy access to multiple functions on a device small enough to fit into your pocket. The keyboard and the touch screen have become the two most common interfaces.

### Keyboard

A variety of different keyboards have been incorporated into most mobile devices (although some are touch screen only). Manufacturers have tried to overcome the limitations of space with various designs or techniques, some of which are listed below:

- detachable keyboards
- scroll wheel
- thumb wheel
- multi-touch.

### Touch screen

The touch screen has played an important role since the days of the original PDAs and has appeared in various incarnations ever since.

The original touch screens provided a limited number of options but modern versions provide multi-level menus and the ability to “scroll” through various screens.

Styluses have been used with touch screens combined with a form of handwriting recognition (Graffiti).



The iPhone 4 includes a panel laminated on the glass which uses electrical fields to sense the user's touch. It has a multi-touch feature that can register simultaneous touches. The user can bring up different information or menus by actions such as swiping, tapping and pinching. Information is displayed on the panel using a “Retina display”.

This display contains a high pixel density (326 pixels per inch) that provides clear, sharp images.<sup>3</sup>

<sup>3</sup> [www.apple.com/iphone/design](http://www.apple.com/iphone/design)

## Generations

The communications industry has found it convenient to refer to major advances in mobile phone technology in terms of generations, a generation appearing approximately every 10 years. The International Telecommunication Union<sup>4</sup> has attempted to standardize the industry by detailing the features expected in each generation, some of which are listed in the table below.

1G	1979	<ul style="list-style-type: none"> <li>• First generation deals with the analog transmission of data.</li> </ul>
2G	1991	<ul style="list-style-type: none"> <li>• Digital transmission of data.</li> <li>• Speed in terms of Kilobits per second.</li> </ul>
3G	2001	<ul style="list-style-type: none"> <li>• Much faster speeds (in terms of Megabits per second).</li> <li>• Good for multimedia/video streaming.</li> <li>• Data sent in packets.</li> <li>• Simultaneous use of speech and data services.</li> <li>• New frequency bands, higher data rates and non-backwards-compatible transmission technology.</li> <li>• 3G networks offer greater security than their 2G predecessors. By allowing the equipment to authenticate the network it is attached to, the user can be sure the network is the intended one and not an impersonator.</li> </ul>
4G	2011	<ul style="list-style-type: none"> <li>• Speed in terms of Gigabits per second.</li> <li>• All networks will be IP packet-switched.</li> </ul>

[Source: adapted from [www.brighthub.com/mobile/emerging-platforms/articles/30965.aspx](http://www.brighthub.com/mobile/emerging-platforms/articles/30965.aspx) and <http://asia.cnet.com/reviews/mobilephones/0,39050603,39242481-2,00.htm>]

New technologies can either be known as:

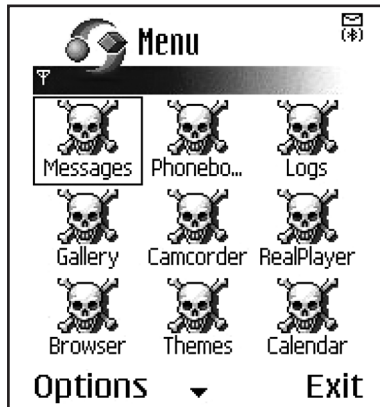
- a *revolution* (not backwards-compatible so a new frequency spectrum is needed)
- an *evolution* (which can use the same frequency-bands).

<sup>4</sup> [www.itu.int](http://www.itu.int)



## Security

Smartphones are as susceptible as normal computers to attacks from outside sources including viruses, phishing and social engineering efforts. However, as no one operating system dominates the smartphone market, data is more likely to be compromised by leaving the device in the back of a taxi than through virus attacks.<sup>5</sup>



### Symbian Skull Virus

This virus produces a flashing skull animation in the background regardless of what application is being used.<sup>6</sup>

Following the advice given below will reduce the chances of data loss:

- encrypt all data that a smartphone receives
- clear all caches after each VPN (Virtual Private Network) session
- choose one with a “kill” switch
- password before opening applications such as e-mail, web browser
- keep data permanently in your data centre, not on the smartphone
- some companies can wipe the data off your stolen smartphone remotely
- only run *apps* approved by the phone company
- do not use unsecured Wi-Fi networks (to avoid “man-in-the-middle” attacks)
- do not “jail-break” your smartphone.<sup>7</sup>

<sup>5</sup> [http://news.cnet.com/8301-27080\\_3-10424759-245.html](http://news.cnet.com/8301-27080_3-10424759-245.html)

<sup>6</sup> <http://computer.howstuffworks.com/worst-computer-viruses5.htm>

<sup>7</sup> [http://news.cnet.com/8301-27080\\_3-10424759-245.html](http://news.cnet.com/8301-27080_3-10424759-245.html)

## ***Smartphone Applications***

The smartphone manufacturers main target has been the general public (particularly the young) who want to be in touch whenever and wherever, and business people, many of whom now see their phone as indispensable in organizing their working lives.

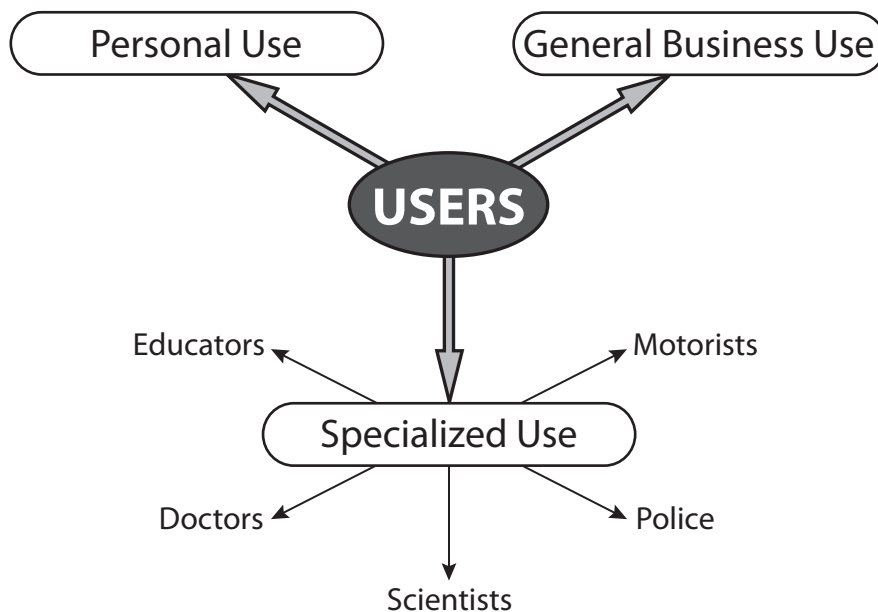
However the smartphone is increasingly finding its way into specialized markets, either by the manufacturers themselves customizing their units to a particular profession or fuelled by the application (*apps*) market which allow users to download specific software modules developed by independent companies.

One such targeted market is the medical profession, which is fast swapping its pagers for smartphones. Links to reference material have become standard aids for many doctors, but increasingly specialized applications are becoming available. One such application not only alerts them to emergencies (as would a pager) but automatically accesses and displays information from the relevant patient's files or lab results.

Others are able to link in with monitoring equipment that can send data from, for example, an ambulance that is bringing in a patient or images from equipment monitoring a pregnant woman in the hospital.

However, there are concerns regarding privacy of data and data security with such applications.

The diagram below shows a small selection of the different uses of a smartphone.



## ***Effects on Society***

Mankind's development has been driven in part by social instincts, the desire for improving quality of life and the need for better and better communication. Rapid technological advances, particularly over the last two decades, have led to the ability to be connected 24/7. However, opinion is divided on the effect that this has had on the quality of life of users. Consider the following articles.

### **Article 1**

#### **Always On: One Third of Employees Feel the Need to Stay Connected 24/7**

For a lot of us, the Internet has made it possible to work from anywhere and connect to work at any time. Without a doubt, this 24/7 connectivity is both a blessing and a curse. According to a new survey by web conferencing firm InterCall, 30 % of workers in the U.S. who use technology to do their jobs feel the need to stay connected to work 24/7, even during weekends, breaks and holidays. One in two workers also say that taking time off is becoming increasingly challenging.

Clearly, the current economic climate isn't helping employees to relax. Almost 40 % of all respondents noted that they are doing the job of two people because of the impact of the economic recession on their company. Today, 25 % of workers think that their supervisors expect them to be online and connected to work after hours and that their job security depends on this. Almost 15 % of respondents say that they plan to attend at least one work-related call or web meeting during their next vacation and 17 % say that it is frowned upon if they don't connect to work during their vacations.

[Source: from an article by Frederic Lardinois on the website [www.readwriteweb.com](http://www.readwriteweb.com), 20 April 2010]

### **Article 2**

#### **My Mobile Phone**

"It's right by my bed when I go to sleep and right by my bed when I wake-up and it's like the first thing I go to," 15-year-old Sarah Matzkin told CNN.

"If someone responds right away, you're like yay they responded and if someone responds two to three hours later you're like, what's going on?"<sup>8</sup>

<sup>8</sup> <http://connecttheworld.blogs.cnn.com/2010/04/20/are-you-addicted-to-your-mobile-phone>

## *Welcome to the Future*

It would seem that today's smartphone has everything: a combination of mobile phone, computer, web browser, camera, social networking device, amongst others, and at a size to fit in your pocket. What more could you want? Yet, in 10 years time, today's "must-have" devices will be consigned to the trash can, to be replaced by new products of man's ingenuity, fuelled by the knowledge that people will continually be seduced by the "next big thing".

Nobody can be completely sure of just how mobile devices such as the smartphone will evolve, but each company's research teams will already have their own ideas about how the future might unfold.

One such idea is Nokia's concept phone, *Nokia Morph*<sup>9</sup>, which suggests how nanotechnology may become involved in transforming our phone into the ultimate fashion accessory. Why should the phone look like a phone when it can become a bracelet, a pendant, or basically anything else that looks good?



### **Nokia Morph**

- flexible materials
- transparent electronics
- self-cleaning
- charged by solar power
- senses our environment

[Source: [www.nokiablog.nl](http://www.nokiablog.nl)]

<sup>9</sup> [www.youtube.com/watch?v=IX-gTobCJHs](http://www.youtube.com/watch?v=IX-gTobCJHs)

***Appendix I – Abbreviations used in the case study***

- GHz – Gigahertz
- GPS – Global Positioning System
- IP – Internet Protocol
- PIM – Personal Information Manager
- RISC – Reduced Instruction Set Computer
- USB – Universal Serial Bus
- VPN – Virtual Private Network

***Appendix II – Additional terminology to the guide***

- 1G, 2G, 3G, 4G
- “apps”
- backwards-compatible
- Bluetooth
- cells (in mobile phone networks)
- firewire
- frequency reuse
- frequency hopping
- Graffiti
- hot-spots
- infra-red
- “kill” switch
- “jail-break”
- “man-in-the-middle” attack
- multi-touch
- nanotechnology
- open-source
- PDA
- phishing
- piconet
- scroll wheel
- social engineering
- stylus
- synchronization
- thumb wheel
- USB connectors
- video streaming
- virtual private network
- Wi-Fi
- WiMAX

### ***Appendix III – Bibliography***

*All about Symbian.com*

URL: [www.allaboutsymbian.com/features/item/Keeping\\_It\\_Clean.php](http://www.allaboutsymbian.com/features/item/Keeping_It_Clean.php)

*Apple*

URL: [www.apple.com](http://www.apple.com)

*ARM*

URL: [www.arm.com](http://www.arm.com)

*Blackberry*

URL: <http://na.blackberry.com/eng/devices>

*Bluetooth*

URL: [www.bluetooth.com/English/Products/Pages/Bluetooth\\_Low\\_Energy\\_Technology\\_Advantages.aspx](http://www.bluetooth.com/English/Products/Pages/Bluetooth_Low_Energy_Technology_Advantages.aspx)

*Cnet news*

URL: <http://news.cnet.com>

*How Stuff Works*

URL: <http://electronics.howstuffworks.com/bluetooth2.htm>

*Memory Breakthroughs Will Propel Smartphone Development*

URL: [www.smartphonemag.com/cms/\\_archives/Sep05/memory.aspx?page=0%2C1](http://www.smartphonemag.com/cms/_archives/Sep05/memory.aspx?page=0%2C1)

*Smartphones*

URL: [www.pcworld.com/article/199243/a\\_brief\\_history\\_of\\_smartphones.html](http://www.pcworld.com/article/199243/a_brief_history_of_smartphones.html)

*Smartphone security lacking at many businesses*

URL: [http://searchsecurity.techtarget.com/news/column/0,294698,sid14\\_gci1348589,00.html](http://searchsecurity.techtarget.com/news/column/0,294698,sid14_gci1348589,00.html)

*Smartphone security put on test*

URL: [www.bbc.co.uk/news/technology-10912376](http://www.bbc.co.uk/news/technology-10912376)

*Symbian Ships Nearly 300,000 Devices A Day In Q2 2010.*

URL: [www.symbian.org/news-and-media](http://www.symbian.org/news-and-media)

*Virus writers hit Google Android phones*

URL: [www.bbc.co.uk/news/technology-10928070](http://www.bbc.co.uk/news/technology-10928070)

*What really is a Third Generation (3G) Mobile Technology*

URL: [www.itu.int/ITU-D/imt-2000/Documents/IMT2000/What\\_really\\_3G.pdf](http://www.itu.int/ITU-D/imt-2000/Documents/IMT2000/What_really_3G.pdf)

---