Viruses, Worms and Trojans on mobile phones

Seminar *Mobile Security*

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Disambiguation

- Topic: "*Viruses, Worms and Trojans* on *mobile phones*"
- Viruses, Worms and Trojans
  - Neglect differences → ***"malware"***
- Mobile phones
  - Modern smartphones (OS and apps)
  - **But:**
    - Tablets, Pocket PCs
    - Feature phones (Java)

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History of “mobile malware” I

- Cabir: First malware “in the wild”
- June 2004
- Worm for Symbian

- Spread via BlueTooth, sends installer to next best discoverable device:
  - Recipient has to confirm manually
- Proof-of-concept, **no harm done**

History of “mobile malware” II

- **But**:
  - BlueTooth distribution revolutionary, inspired future malware writers
  - Source code of Cabir was published → new dangerous variants
- In 2005 “CommWarrior” spread additionally via MMS

History of “mobile malware” III

- 2004-2011
  - New mobile phone operating systems (Android, iOS, WebOS, Windows Phone...)
  - Increasing distribution of J2ME
    - Sand-boxed execution, harming phone is difficult
    - **But**: allows for sending SMS to premium rate numbers, **cross-platform** SMS trojans

History of “mobile malware” IV

- Summary (2004-2011):
  - Spread via 3rd party app-store & WAP portals
    - Trojans with direct financial gain (premium rate numbers, e.g. J2ME SMS trojans)
    - Rendering device useless (e.g. Skuller)
  - Very **few** powerful attacks with goal to steal data:
    - Proof-of-concept implementations by researches (bugging/spying on the phone)
    - Only few successful black-hat distributions so far (e.g. WinCE.InfoJack, Android Geinimi, SymbOS.Yxe, iOS firmware v1.1.3...)

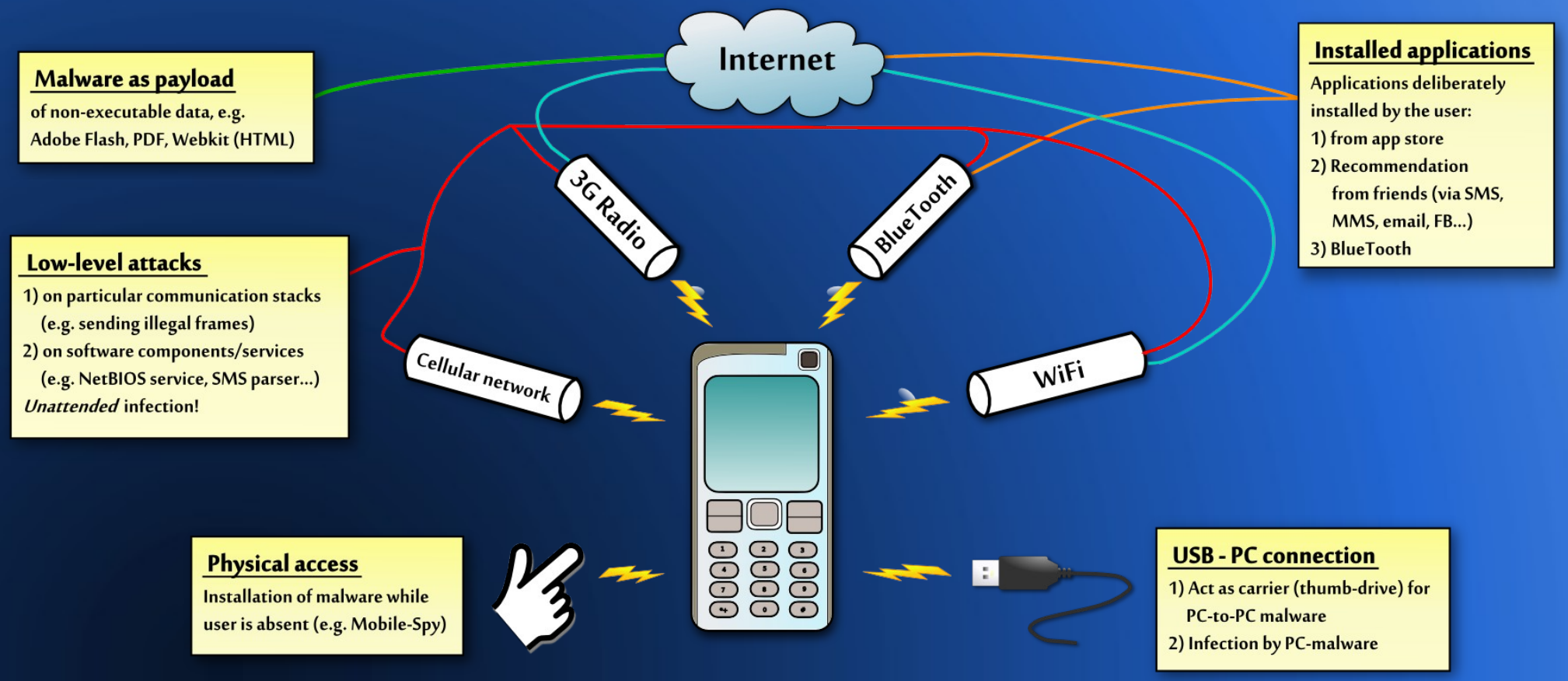
Goals of malware

- Depends on author
  - White-hat hackers (researchers): Develop proof-of-concept implementation
    - Raise attention, (OS programmers, AV specialists)
    - Usually spread via 3rd party app stores
  - Black-hat hackers: earn money, execute power, or simply harm the victim

Goals of malware II

- Earn money
  - Call/text premium rate numbers
  - Steal banking data
  - Harvest data, sell to 3rd parties (enterprise information!)
- Exercising power
  - Trojan horse with back-door (remotely control or bug the phone, e.g. tap phone calls, text messages, GPS location...)
- Harming the user...

Attack vectors

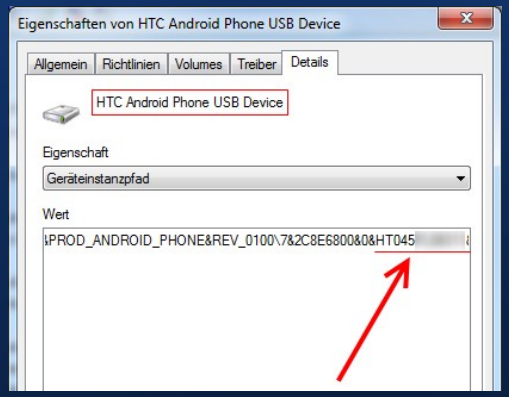


Attack vectors: USB connection I

- Phone (SD card) mounted as USB thumb-drive
  - PC ↔ PC infection: Allows infected computer to spread malware to other computers
    - Auto-run no longer works → manual execution
  - Phone → PC infection: Infected phone, place PC malware on SD card (e.g. inject into existing binaries)
  - PC → phone infection: Infected computer identifies the phone and places malware on it

Attack vectors: USB connection II

- Phone (SD card) mounted as USB thumb-drive (continued)
  - PC → phone infection (continued):



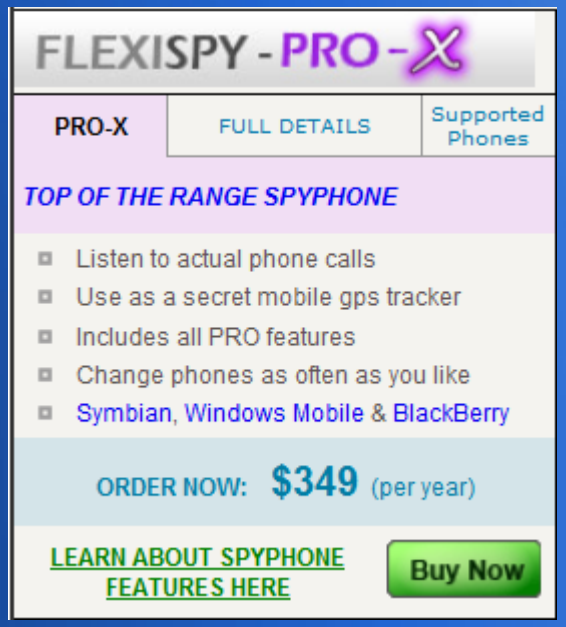
Exact serial number

- Identification of the exact phone model is possible with some models
- Idea: guess phone's OS, place malicious file on SD card, will be processed by phone's application (e.g. gallery thumbnail)

- Infect phone via synchronization mechanisms
  - "Crossover" (02/2006) spread from Windows PC to Windows Mobile/CE phone via ActiveSync

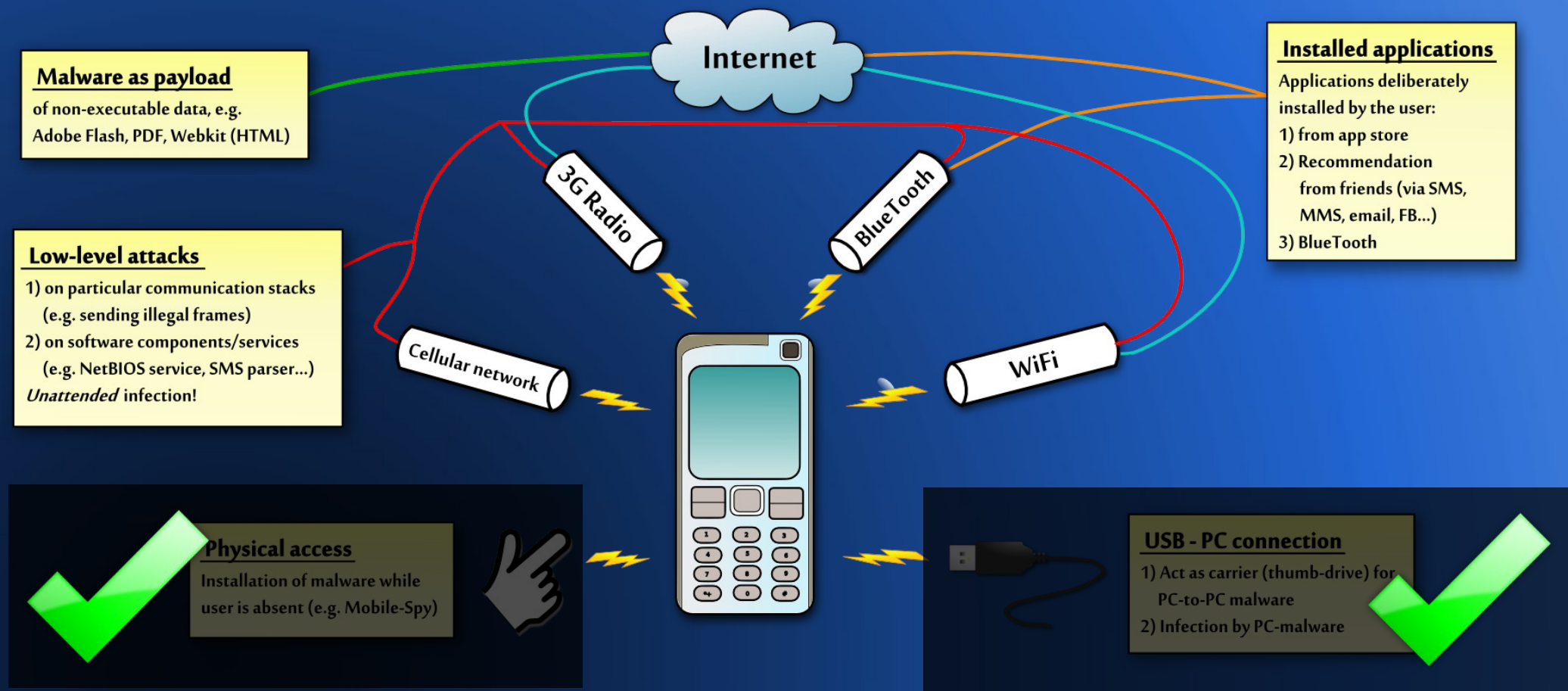
Attack vectors: physical access

- Gain physical access to someone's phone in their absence, install spyware (e.g. via download)
- There actually is legally purchasable spyware:



- Used by “concerned” husbands, parents, employers

Attack vectors



Attack vectors: low-level attacks I

- Sending/receiving data over 3G, WiFi, BlueTooth, radio controlled via drivers (*software stack*)
  - Vulnerabilities can be found via "fuzzing"
    - Send random data *frames* to the stack, check for crashes of the targeted process, examine for possibility of code execution
  - Drivers run in kernel space → *jackpot* if security issues are found

Attack vectors: low-level attacks II

- On the next higher level:
  - Attack components in charge of SMS and MMS processing
  - Target permanently running services, e.g. naming services (NetBIOS, Bonjour)
- All this is not just theory!
  - Successful attacks on SMS and MMS stacks already illustrated
  - Bluesnarfing (attack on BlueTooth stack)

Attack vectors: high-level attacks

- High-level attack = user installs application
  - Source: 3rd party or official app stores
  - Apps claim to have a valid purpose (banking application, game...), but come with a malicious component → "trojan horse"
  - Installation by own initiative or (fake) recommendations from friends → higher level of trust

Attack analysis

- Now: analysis (advantages, disadvantages) of
  - Low-level attacks
    - Stack implementations
    - Malware as payload
    - PC → Phone via USB
  - High-level attacks
    - Installing apps
    - (Physical access)

Attack analysis: low-level attacks

- Advantage: unattended infection
- Disadvantage: efforts for the malware developer:
  - Malware developed in two stages
    - Stage 1: Develop functionality (high-level, C) and the machine code to be injected into buffer (time consumption *fixed*, 13 weeks, fulltime)
    - Stage 2: Find an application with buffer-overflow vulnerability (time consumption *variable*)

Spreading of low-level attacks

- Unattended infection ↔ real-world virus infection (e.g. influenza)
- Outbreaks (Windows), e.g. Nimda or ILoveYou
  - And in the world of mobile phones? Nada! Why?!
- → Examine spreading pattern considering the technologies, MMS and BlueTooth

Spreading using BlueTooth I

- Infects devices in its proximity (as does a real virus) → "proximity malware"
- P. Wang et al, *"Understanding the spreading patterns of mobile phone viruses"* (04/2010) conducted experiments, using a mix of mathematical mobility models and collected mobility data from cellphone-towers
- BlueTooth malware eventually reaches all susceptible devices
  - Higher market share → faster spread

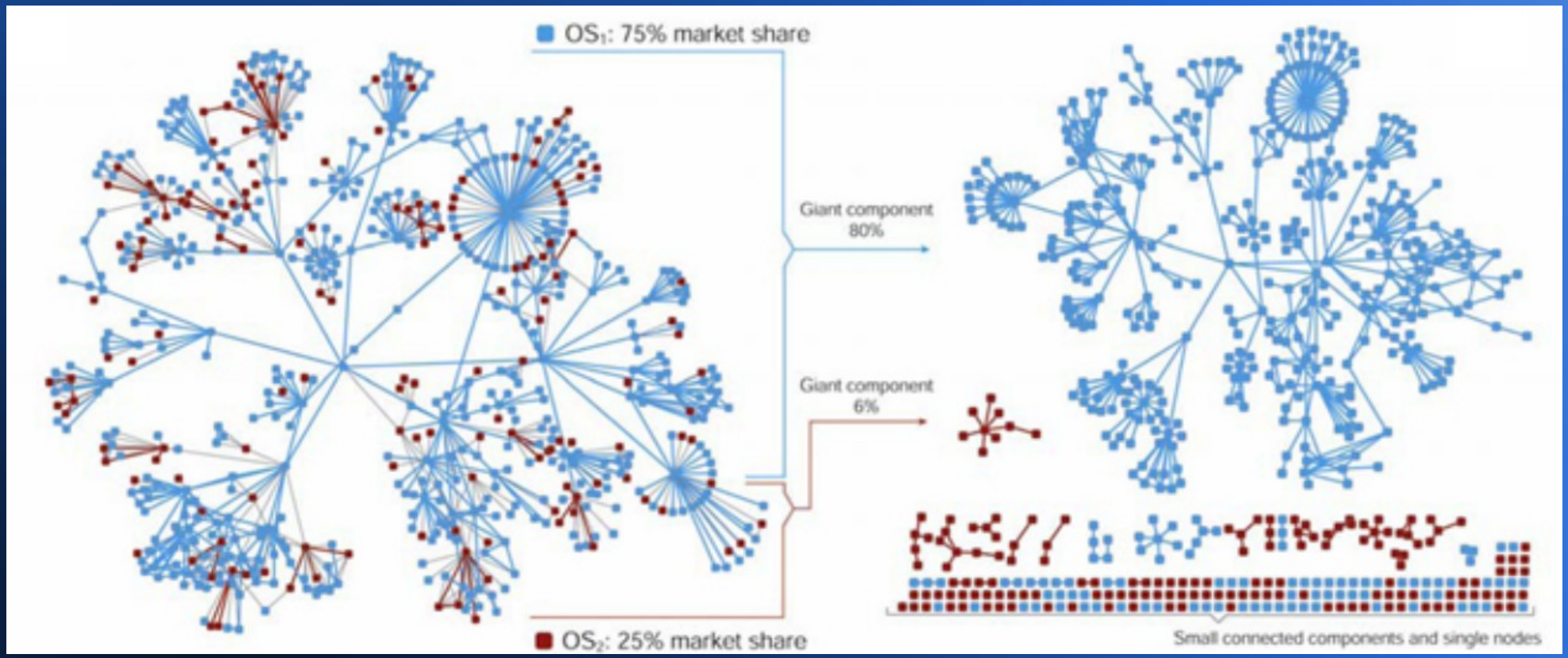
Spreading using BlueTooth II

- Exemplary:
  - m = 0.3 (30%) → 85% of devices infected in a few hours
  - m = 0.01 (1%) → completion of infection takes several months
- Consider Symbian (at the time m_{symb} = **0.643**)
  - But: m_{symb} is the *relative* market share: multiply with m_s = market share of smartphones = **0.05**
  - $m_{symb} * m_s$ = **0.032** (3.2%)

Spreading using MMS messages I

- Sending MMS messages → proximity-*independent*
- P. Wang et all illustrate, spreading using MMS
  - Depends on *m*
  - Depends on underlying graph representing connections between users

Spreading using MMS messages II



- "Percolation transition point" $m_c \approx 0.095$ (9.5%)

Spreading patterns: result

- Smartphones still the minority on the phone market
- But: Smartphones are a new phenomenon
  - Sales figures are constantly climbing (Gartner, 08/2010)

	Units sold (Q2/09)	Units sold (Q2/10)
Total	286'122'300	325'556'800

  - This will grow even stronger, as Eric Schmidt (Google) suggests: *"We want to increase the availability of inexpensive smartphones in the poorest parts of the world. We envision literally a billion people getting inexpensive, browser-based touchscreen phones over the next few years"*

Attack analysis: high-level attacks

- Advantage: malware developer can focus on functionality (use high-level API)
- Disadvantage:
  - Manual installation by the user, grant requested access rights
    - But: User will assume apps from the *official* store are *safe*
  - Costs incurred to publish app in official store
    - But: Costs usually low compared to earnings (even with Apple's app-store fee of $99)

High-level attacks: Trustworthiness

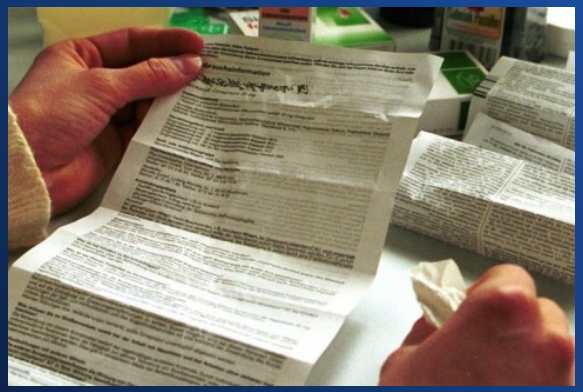
- Q: Trust in the safety of official apps justified?
- Apple performs static and dynamic code analyses (can be tricked)
- Other parties (Google, RIM...) sell "official" keys to developers, sign and publish apps
  - Incurred fees ($0 - $25) are *nothing* compared to potential earnings

High-level attacks: Security models

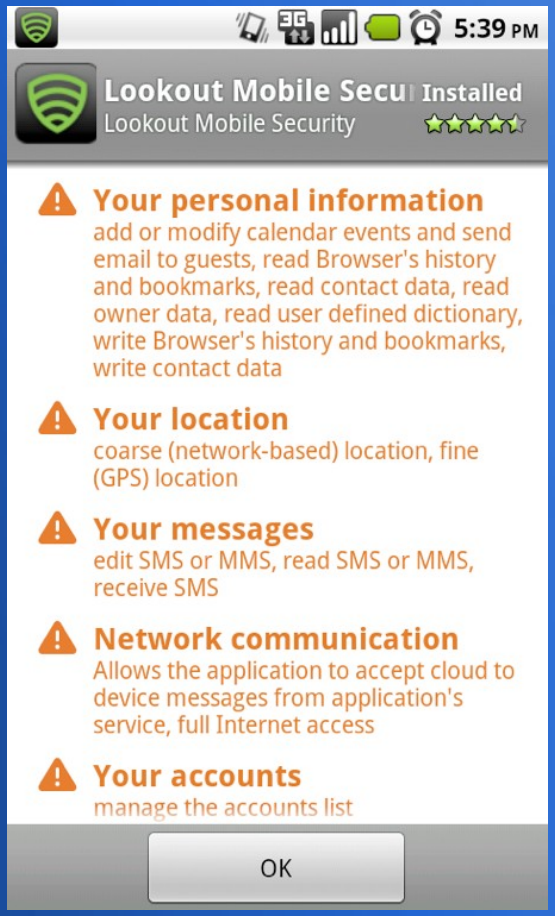
- Mobile phone OSes come with a "security model"
  - User controls HW/SW components the app may access
- Problems:
  - User swamped with technical concepts and terms
    - Becomes overburdened, loses interest
  - Access rights insufficient for decision (e.g. movie player vs SMS tool)
  - User is *"trained"* to accept any requested access

User permissions: Example

- Looks like a package insert of your favorite drug... Who reads that again?



- Result: TrendMicro survey: *"Only 23% of the users use the security features..."*



Prevention of infection I

- Operator of the **app-store**: introduction of static and dynamic analyses to reduce chance of malware being published
- Programmer of **OS**: tighter default values for security framework
- **Network provider**: collaborate with AV specialists to minimize infection over provider-controlled channels (SMS, MMS, 3G internet)

Prevention of infection II

- **User**:
  - Use anti-virus software
  - Disable BlueTooth (avoid proximity malware)
  - Use locking mechanisms (prevent 3rd party infecting the phone physically)
- **Society**: Advertise the threat of malware to mobile phones. Apply knowledge from the PC world to the mobile phone

Outlook

- High-level attacks in near future
  - User-base will keep ignoring the risk, until enough severe incidents have happened
- Market share of smartphones will rise, attacks will become increasingly worthwhile
  - Outbreaks like Nimda? Predominant platform?
- Low-level attacks: a niche-product until war of mobile operating systems has settled?

Thanks for listening

The End

Supplementary material

Comparison: PC vs. mobile phone

- Malware attacks are well-known from the ~~PC~~ *Windows* world
  - Symantec Antivirus detected **1'122'311** malicious programs in 04/2008
- For mobile phones (Kaspersky, 09/2009):

Operating system	Number of variants
Symbian	253
J2ME (Java Microed.)	182
WinCE/Mobile	26
Others	54

- Doesn't even reach 1'000

History of “mobile malware” eI

- **Skuller**, detected in 11/2004
  - Cabir's spread method
  - Exploited Symbian OS vulnerability
  - Removed application executables and replaced icons with skulls
  - In disguise as “Extended theme”:

History of "mobile malware" eII

- **CommWarrior**, created in 03/2005
  - Spread via BlueTooth, to **all** discoverable phones
  - **Additionally** spread via **MMS** (payload 30 KB)
  - Over 20 interesting message titles, such as *"3DNow! 3DNow!(tm) mobile emulator for *GAMES*"*, or *"WWW Cracker Helps to *CRACK* WWW sites like hotmail.com"*
    - Safe-guard to not affect other insiders(?)
  - No purpose other than spreading → classify as *worm*