Mag. iur. Dr. techn. Michael Sonntag

Introduction to Computer forensics

Computer forensics

Institute for Information Processing and
Microprocessor Technology (FIM)
Johannes Kepler University Linz, Austria

E-Mail: sonntag@fim.uni-linz.ac.at
http://www.fim.uni-linz.ac.at/staff/sonntag.htm

Agenda

- What is computer forensics?
  - → When and where is it used?
  - → Who may use such techniques?
- Computer forensics vs. encryption
- Computer forensics vs. steganography
- Securing evidence
  - → Running systems
  - → "Inert" systems
- What information can be obtained in which circumstances?
- Legal aspects:
  - → Classifying information to look for according to crimes
  - → Admissibility of evidence

What is "Computer Forensics"?

- Computer Forensics (CF) is obtaining digital evidence
  - » Analogue evidence is usually not considered here: Use "ordinary" forensics to gather/evaluate
    - – Analogue computers are almost non-existing today!
  - → This may come from running systems or parts of them
    - » Hard disks flash drives, PDAs, mobile phones, telephones etc.
  - → Can be evidence for computer crimes (computer fraud, hacking, …) or any other crime (documents with plans for x) or for various other uses

- One indispensable issue is "data integrity"

  Data is easily changeable:

  Evidence is **then and only then** usable in proceedings, if it is **ensured**, that it **has not been changed**!

What is "Computer Forensics"?

- Other definitions:
  - → Analytical techniques to identify, collect, preserve, and examine evidence/information which is magnetically stored or encoded
    - » Problem: "magnetically" → Flash disks, running systems?
    - » Better: "in computerized systems and their parts"
  - → We define computer forensics as the discipline that combines elements of law and computer science to collect and analyze data from computer systems, networks, wireless communications, and storage devices in a way that is admissible as evidence in a court of law.
    - » Focus on legal proceedings; there are many other uses as well!
      - – Note that this is the "highest" form: If evidence is sufficient for criminal proceedings, it can be used for everything else as well!
  - → A technological, systematic inspection of the computer system and its contents for evidence or supportive evidence of a crime or other computer use that is being inspected.

What is "Computer Forensics"?

- Three main elements:
  - → Has something happened at all?
    - » Random effect, bugs, …
  - → What has happened and what are the effects?
    - » What are the results from the intrusion/…and what is their direct and indirect "cost"?
  - → Who was responsible for it and how did he do it?
    - » Can we identify an IP address or a person?
    - » How did the intruder enter → So we can block this?

The basic principles of CF

- No action to secure/collect evidence should affect its integrity
  - → It becomes much less worth/completely worthless!
- Examiners should be trained
  - → Only investigate as far as your knowledge goes
- All activities should be logged
  - → Seizure, examination, storage, and transfer
    - » Complete chain of custody (including its security measures)
  - → Documented, preserved, and available for review
    - » Proof for the chain of custody
- Investigations must be accurate and impartial
  - → Computer forensic ≠ prosecutor/attorney/judge
    - » Describe what was actually found
      - – And what should have been found, but was missing!
    - » Describe how reliable these facts are
    - » Describe what conclusions can reasonably be drawn from it

When to use CF?

- To provide digital evidence of specific activity
  - → In general, proving non-activity might also be the goal, but this is more difficult and only sometimes possible!
- For legal proceedings
  - → Criminal cases: Child pornography, computer fraud, ...
  - → Civil cases: Hacking, information theft, industry espionage, …
- Recovering data
  - → (In)advertently deleted information
- Identifying weaknesses
  - → After a break in, identify the method employed to prevent it in the future
- Identifying the attack/attacker
  - → Verify, whether an incident actually happened and who was responsible for it

When to use CF? Concrete examples

- Misuse of ICT by employees
  - → Unauthorized disclosure of data
  - → Internet (WWW, E-Mail, …) abuse
  - → Deleted/damaged information
- Exploiting ICT
  - → Industrial espionage
  - → Hacking of systems
  - → Infiltration (zombie, trojans, viruses, …)
- Damaging ICT
  - → Web page defacements
  - → Denial of Service attacks
  - → Crashing computers
- Use of ICT
  - → Storing data on various (planned) crimes

Who should/may use CF?

- Authorization required for accessing data
  - → See privacy laws!
- Live monitoring, hacking, password cracking etc. tools are legally very "dangerous"!
  - → Possession alone might be criminal
    - » Good explanation and evidence for its necessity is required!
- Personnel to "do" CF:
  - → System administrators in their own area
  - → Experts for courts or private investigations
  - → Everyone on their own system
    - » Note: A second person (→ e.g. husband/wife) uses the system means, that consent by this person is indispensable!

Where to find evidence

- Disks: Hard disks, USB-Disks, floppy disks, tapes, …
  - → The typical "storage medium"
  - → Note: These can be very small and very easily hidden
    - » They might also pose as "normal" objects
      - – Example: USB-Stick in pocket knife!
- Devices: Mobile phones, PDAs, MP3 players, USB sticks, game consoles, …
  - → Directly or in disks contained therein
  - → Not a storage medium, but usually may contain arbitrary data
    - » In addition to the "normal" data like music, contacts etc.!
- Recorders: Cameras, audio recorders, GPS trackers, …
  - → Similar to devices: Own data + any other stored data
- Digital copiers/printers
  - → Might add a serial number to each copied/printed sheet!
  - → May contain old scanned pages

The sequence of actions in CF (1)

- Secure and isolate
  - → Remove all other personnel
  - → Keep reliable witness (police, other third persons)
    - » To protect against "The investigator added this data!"
- Record the scene
  - → Photograph, write down
    - » Example: Mouse on left or right side? → Left-/Right-handed
    - » How are the systems connected (WLAN!)?
    - » What is the current state (running; screen content; …)
  - → In many cases there is quite a mess + lots of cmputers/devices/…
    - » You won't remember exactly where the disk was and whether it was powered
      - – Example: Disk behind desk? Fell down or deliberately hidden?
      - – Example: Computer running → Might act as a server

The sequence of actions in CF (2)

- Conduct a systematic search for evidence
  - → Especially: Notes with passwords, hints for online services used, storage mediums (USB sticks, flash cards etc.)
    - » More "conventional" search, but important
    - » E.g. steganography impossible without programs → Disks, …
  - → Printouts in waste paper basket, …
  - → Empty storage media ("commercial distribution"?)
- Collect and package evidence
  - → Keep it safe (no loss/destruction) and secure (no changes)
    - » Secure wrapping; external influences
    - » Especially: Magnetic media and magnet fields
      - – Modern harddisks are resilient, but not all media are as safe (e.g. magnetic stripe cards)!
    - » Flash cards, USB sticks, etc.: Static electricity
  - → Ideally: Make copies there and package & take both!

The sequence of actions in CF (3)

- Maintain chain of custody
  - → Keep log on who has access and restrict this access
- Inspect and evaluate data
  - → The main aspect we are going to cover here!
  - → Perhaps triage: Immediate brief investigation
    - » What to impound, already some illegal material found → arrest
  - → Detailed investigation in lab (from copy of media!)
  - → Create report:
    - » What was done, what was found, what was not found, what should have been found, how searched, confidence in results, …
- Present the results
  - → In a report
  - → Potentially also before the court
    - » Oral (cross-)examination probably
- Potentially answer questions/respond to counter-expertises

Chain of Custody

- Guaranteeing identity and integrity of the evidence
- Requirements:
  - ❶ Making sure, the piece of evidence introduced is the same as was taken from the suspect/scene of crime/….
    - » Serial numbers → All harddisks/USB/… look exactly the same!
  - ❷ Making sure there was no tampering with it
    - » Witnesses of actions, trust in the person
  - ❸ Making sure of the transition to the next custodian
    - » Who got it next, i.e. when was a chance for tampering
      - – Lying around somewhere? Handed to a untrusted person? …
  - → Repetition of ❷ and ❸ until the presentation in court
- Note: Digital evidence has a very nice property here: Hash values can nicely prove the "no tampering"!
  - → Acquire as early and trustworthy as possible
  - → Store it "securely", e.g. on paper with signature of third person

The main problems of CF

- Anything done to a system changes it
  - → Especially problematic for running systems
  - → Usually not a problem for hard disks
    - » Reading data may change the content microscopically …
- You can never trust the system under investigation
  - → It may be hacked, modified by the owner etc.
- Proving you did not change anything is difficult
  - → You must be "above suspicion" and take precautions
- The past can never be known
  - → We can only find hints what might have possibly been
    - » The content could have been manufactured by someone!
    - » This can be pretty good evidence, but no absolute proof
- Not everyone knows everything
  - → Every forensic examination is limited through the examiner!

An increasing problem of CF: Networking & Security

- Today much data is not stored on "the" computer anymore
  - → FTP server, bulletin boards, "online harddisks"
    - » Example: RapidShare and similar services
  - → Webmail accounts
  - → Remote harddisks
  - → VPN networks to other systems
- Obtaining a copy of one system is often not enough today!
  - → Find traces of the existence of remote information
  - → Find traces of the remote information itself
    - » Caches, paging file, file slack, …
  - → Try to access this remote information
    - » By seizure, copying, access over the network, …
- Encrypted disks are difficult
  - → Obtain keys from memory of running system if possible
  - → See also TPM (Trusted Platform Module)

The order of volatility

- Registers, caches
- Memory
- Network state (routing configuration, estab. connections)
- Running processes
- Media in use: Disks in use
- Backup media: Disks not in use, tapes
- WOM: CD-ROMs, DVDs
- Analogue material: Paper, fingerprints, DNA, …

Evidence should be secured/collected in this order !

- Power management (e.g. sleep) can be a great help here
  → Used also normally, so the likelihood of delete-scripts is low)!

Computer forensics vs. encryption

- CF does work, but doesn't bring usable results if the data dis-/recovered is encrypted
  - → Depends strongly on the kind of encryption!
- For some programs, decryption software is readily available
  - → Especially the integrated encryption of MS Office and Zip!
  - → Sometimes based on weaknesses or short keys
    - » But otherwise just brute force attacks: High computing power, special software, and long time may be necessary!
- If really good encryption is used, there is almost no chance of decryption without the key (or brute force)
  - → One of the reason for the hidden searches: Get at the data before/after it has been en-/decrypted!
  - → But: Very often passwords are known words (→ lists!), are written down somewhere, stored somewhere, …
    - » Important to search the environment for any clues!

Data hiding methods

- Numerous approaches to hide data exist :
  - → Through the operating system
    - » Mark as "hidden", "system", ...; use ADS
  - → File extension modification: "order.txt" → "cmd.com"
  - → RAM slack: End of file → End of sector
  - → File slack: End of file → end of cluster
  - → Partition slack: End of partition → end of track
  - → Disk slack: End of last partition → end of disk
  - → Unallocated/bad sectors
  - → Delete file / partition; format disk
  - → Steganography
- Attention: Several methods are "unstable", i.e. further actions might destroy the data → Using such methods is complex!
- Many approaches require special programs (Hints!)

Introduction to Steganography

- Steganography: Hiding messages
  - → The intention is, that there is no sign, that data exists at all
- Typical "recipients": graphics, HTML, text, executables
  - → Usual problem: Only a small part of the content data can be used for hiding information → Large "cover" for little "content"!
- Usage areas:
  - → Where encryption is illegal
  - → When the fact of communication itself should be hidden
- Combining encryption and steganography
  - → Makes detection through statistics much harder!
- Relation to computer forensics:
  - → Hiding data in "inaccessible" places is steganography too
  - → Examples: Various slack spaces, alternate data streams
    - » Rather easy to uncover, if presence is known!

Problems of Steganography

- Not very resilient:
  - → Data hidden in images is easily destroyed through recoding
  - → Text can be reformatted
- Not all base data is suitable:
  - → Many files are exactly "known": E.g. OS files cannot be used to hide data within them
    - » See also the problems caused by signed code!
- Complicated to use: Additional tools necessary
  - → These can be found on the computer, disks, USB sticks, …
    - » But need not necessarily be installed!
- Large pieces of seemingly important base material needed
  - → This is not always available, or is a hint to hidden data
- Requires a high level of knowledge to be "good"
  - → Free tools are available, but these are often easily detected!

CF vs. Steganography

- In practice, Steganography seems to be rather rare
  - → There are much easier methods for hidden communication!
    - » E.g. the personal ad columns with certain pre-defined texts
    - » If the text to hide is very long (or multiple pictures, videos), Steganography is still problematic
- Still, looking for hints that it has been applied should be part of every investigation
  - → Are there any traces of Steganography programs?
  - → Is there suspicious data?
- Brute force attacks, e.g. using steganalysis programs on all images on a computer, are probably less useful
  - → Takes very long and it's not very probable to find anything
    - » Mostly, the programs only "support" specific tools!

Securing evidence: General considerations

- Evidence must be secured in a "trustworthy" way
  - → Nobody should later be able to question the authenticity
- Evidence should be collected as fast as possible, but without destroying anything
  - → This might mean, keeping some devices powered, others without power
    - » Keep with power: mobile phones, PDAs, fax machines, …
    - » Store without power: Flash disks, hard drives, computers
  - → Disconnect any communication to/from the device
    - – Attention: Not necessarily immediately!
    - » E.g. mobile phones: Shielding (no powering off!)
    - » Computers: Network cables, phone lines, serial lines etc.
  - → Check with other forensic experts: Fingerprints
    - » Obtaining traces can damage electronic media!

Securing evidence

- Secure the scene
  - → Preserve potential fingerprints, ensure personnel safety
  - → Immediately restrict access to computers
    - » Physically; electronically comes next!
  - → Document current state (hardware & software)
- Secure the computer as Evidence
  - → If the computer is "OFF", do not turn it "ON"
    - » Disconnect all power sources; unplug from wall AND computer
    - » Place evidence tape over each drive slot
    - » Photograph/diagram and label back of components with existing connections
    - » Label all connectors/cable end to allow reassembly as needed
    - » Package components and transport/store components as "fragile"
    - » Keep away from magnets, radio transmitters, heated seats, etc.
- Interview all persons/witnesses

Securing evidence: Online computers (1)

- → If the computer is "ON"
  - » Stand-alone computer (non-networked)
    - – Consult computer specialist
    - – If specialist is not available
      - » Photograph screen
      - » Disconnect all power sources; unplug from wall AND computer
      - » Continue as with offline computer!
  - » Networked or business computers / Routers
    - – Consult a Computer Specialist for further assistance, because pulling the plug could:
      - » Severely damage the system
      - » Disrupt legitimate business
      - » Create officer and department liability

- Please note: Typical procedure for non-experts
  - → Experts will (try to) acquire the runtime-state first!

Securing evidence: Online computers (2)

- Better: Obtain as much information from the running system as possible; only then "shutdown" the system
  - → General rule: Do not alter the state (On → On, Off → Off)!

❶ Obtain a copy of the complete state

- → Copy of the complete memory
  - » With as little changes as possible!
    - – Some additional software MUST be started for transfer!
- → Output of various "state" commands, e.g. running processes, open network connections, open files/shares, …

❷ Remove power cable from computer

- » In general, some files might be destroyed, so the computer might not boot anymore. But much less data is lost/changed in this way than when shutting it down!
  - – "Delete paging file on shutdown", "Clear privacy data when I close Firefox", …
- → Not from wall socket: There might be a UPS somewhere!
- → Laptops: Remove accumulator (both if present) as well

Pulling the plug

- Note: Other recommendations are bit more sophisticated
  - → Servers: Shutdown
    - » Much data can be destroyed when a file/database/E-Mail server is "killed", which can be a problem for companies
      - – Data is lost, computer must be reinstalled/backups restored, …
    - » Little danger of deletion/modification scripts
      - – These might be shut down at any point in time by someone else (e.g. by UPS in case of power failure!)
  - → Workstations: Pull plug
    - » Little damage to be done by killing
    - » Usually full control by a single person → Traps much likelier
    - » Restore much quicker and easier
    - » Affects only a single private person, not a huge company!
  - → Appliances: Pull plug
    - » They typically are built to survive this without any damage
    - » The runtime data must be copied before, of course!

The Heisenberg principle - Analogon

- It is impossible to completely capture an entire running system at any point in time
  - → Every kind of "copying the state" will change the state itself!
- The goal to reach:
  - → With as little changes as possible
  - → Without distortion (like installing additional software)
  - → Without bias (like adding hardware/software)
    - » With additional hardware, the data state alone **can** be captured completely and without its modification!
- Decisions are necessary, what to do (and with that tools!)
  - → Generally, try to obtain as much information as possible without changing too much
  - → Examples: Display the running processes and photograph the output on the screen
    - » Even better: Use your own (statically linked) program from a CD

Interviewing personnel/witnesses

- Very important: Encryption, Steganography!
- Information to obtain:
  - → Owner
  - → User names, passwords
    - » PW: Account, BIOS, E-Mail, configuration, network, ISP, applications, token codes, …
  - → Procedures for access (log in method)
  - → E-Mail addresses, online services/applications used, ISP
  - → Purpose of the system, persons using it
  - → Security schemes (self-destruct systems; e.g. delete scripts)
  - → Offsite data: Backups, online replications, …
  - → Documentation of the system: Version numbers
- Note also when information is **not** provided!
    - » Or what turns out to be incorrect
  - → Won't help the investigation, but may be important in court

Guiding the search for information

- The aim of the search is most important
  - → Is it a search for "something illegal", a specific crime, or whether the image "xyz.jpg" is present on the computer?
  - → Uncovering all information that is recoverable is possible, but also a lot of work (and therefore extremely expensive!)!
- Assessing the proficiency of the suspect
  - → What "hiding" can reasonable be expected?
    - » If unknown, always assume the worst, i.e. expert techniques!
- When to stop:
  - → If something matching has been found or must all/the most of such data be recovered?
  - → Monetary considerations (expenses)

Information according to crimes

- Electronic intrusion
  - → Configuration files
  - → Executable programs and source code/scripts
  - → Open ports, running processes (esp. servers)
  - → Logs: Activity, connection, programs, communication, …
- Fraud
  - → Address books, calendars: Physical, E-Mail etc.
  - → Images: Cheques, currency, Western Union, signatures, products, …
  - → Credit card data, esp. CVC
  - → Office documents: Letters, spreadsheets, databases
  - → Banking/accounting software: Dedicated and online
  - → Internet activity: Logs, caches, cookies, …
  - → Account information: eBay, banks, …
  - → Communication history: E-Mails, chat logs

Information according to crimes

- Undesirable communication (threats, spam, mobbing)
  - → Address information: E-Mail, telephone, …
  - → Documents: Background information, diaries, legal etc.
  - → Communication: Letters, E-Mails, SMS, chat logs, …
  - → Internet activity: Cache, logs, cookies
  - → Accounts: Online communication facilities
  - → Images: Person, products, fakes
  - → Software: Mass mailers, text/image/PDF generators
  - → Financial information: Accounts, banking

Information according to crimes

- Violence: Child abuse/pornography, domestic v., death
  - → Images, especially hidden ones, and videos
  - → Date and time stamps
  - → Internet activity: Cache, logs, cookies, access time, searches
  - → Software: Communication, photo, P2P
  - → Address information and communication: E-Mails, chats, tel.
  - → Documents: Legal, medical

Information according to crimes

- Identity theft
  - → Personal information: Name, address, credit card, …
  - → Communication: Especially copies of other person's, obtaining/buying information online
  - → Software: Generators (names, credit card numbers), imaging (scanner, photo modification)
  - → Images: Certificates, forms, signatures
  - → Documents: Forms, letters, orders, …
  - → Electronic signatures
  - → Internet activity: Cache, logs, searches

Information according to crimes

- Copyright
  - → Software: P2P, CD/DVD-burning, encryption, recoding, key generators, cracks
  - → Documents: Serial numbers, authorization information
  - → Internet activity: Cache, logs, searches, cookies
  - → Images: Covers, license forms
  - → Communication information: E-Mail, chat
  - → Accounts: Web-Sites, FTP, shops
  - → Date and time stamps

Admissibility of evidence (1)

- Digital information is no evidence as such alone
  - → Illegal image on disk? How did it come to be there? Unknown!
    - » Was it the accused, someone else with his account, the police, a hacker who broke in over the network, … ?
    - » Additional information can help if present
      - – Physical access to computer, logon-history, encryption etc.
- One very important aspect is the person collecting and interpreting the evidence
  - → If this person is trusted, then no later modifications took place
  - → When a conclusion is stated as a fact, the person will not be very useful, as judges will not believe them
    - » Fact = Observable
      - – Example: Car braking took x meters (measured on asphalt)
    - » Conclusion = Fact + interpretation/general rules
      - – Example: Start speed was y km/h because of known friction of tires, weight of car, laws of physics, …

Admissibility of evidence (2)

- Continental law:
  - → Generally all evidence is admissible, regardless how obtained
    - » But what evidence is worth depends on
      - – How it was collected and stored
      - – By whom it was collected
      - – Who analyzed it
      - – How it was analyzed
      - – Whether the conclusions are supported by facts
      - – Whether the conclusions are "state of the art"
  - → Typically the judge (or a jury) decides
- Common law:
  - → Facts might also be fixed by parties!
    - » If agreed upon, judge/jury cannot discuss it any more
  - → Esp. USA: "fruit of the poisonous tree" doctrine
    - » Evidence obtained unlawfully may not be used

Admissibility of evidence (3)

- Note: There is no "court-approved forensic SW"!
  - → Neither in the USA nor the EU/Austria there is a certification for what things might be used for investigation
- But: Investigation must be done according to state of the art!
  - → Using the "usual" SW is typically state of the art
  - → But other software might also be used, but could require additional explanation in court
    - » Typically the case in the USA!
  - → Europe: Person of investigator is often more important
    - » Officially certified court expert, reputation etc.!
    - » Method is only important if another expert criticizes it
      - – Or the court knows/suspects from other cases that it might be suspect/wrong/incorrectly applied, …

Documenting actions

- All actions during an investigation must be documented
  - → This starts with acquiring the evidence!
    - » Writing down and photographing when/how the computer was found, which state it was in, etc.
- Running systems: Every single command entered must be documented with the time and the complete results
  - → Ideally the log and the result should be stored as a file with a checksum to verify its integrity
- Offline systems:
  - → The state must be exactly documented, e.g. checksums over the whole disk
  - → Every step of the examination should be documented like in a running system
- Generally: Document also tools (make, version, …) used!

Final report: General information

- Identity of the examiner
- Identification of the case, e.g. case numbers
  - → Who commissioned the report?
- Subject of examination
  - → List of and serial numbers of disks/components/…
  - → Source of the equipment
    - » Personally taken from suspect, received from police/court etc.
- Procedural history
  - → When was what piece of evidence received, examined, passed on, reported upon, …
    - » Chain of custody!
  - → Description of examination: Who did what when in which way
    - » Which techniques were used; state of the art?

Final report: General information

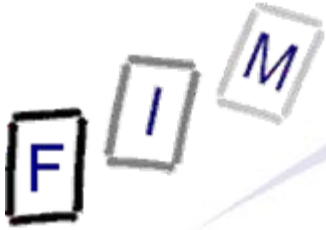
- Results and conclusions
  - → Facts (see next slide): What was found
  - → Conclusions: What can be derived from that?
    - » This must conform to a very high degree and state assumptions!
      - – Example: Time of computer matches "real" time, file access date is 12.12.06 (facts) → File was accessed at that time
        - » Note: Changing the clock, who used the computer, network connections, …?
    - » Includes a reliability assessment:
      - – Not necessarily with a percentage, but should have it if possible!
      - – "Might perhaps be", e.g. 10%
      - – "Almost assuredly", e.g. 99,999%
  - → What was not investigated?
    - » But might be interesting
    - » Reason for this "omission"
    - » What therefore cannot be deduced from the things investigated
    - » What could be in there and what could never (?) be in there

Final report: Content

- Summary of findings (non-technical language!)
- Detailed findings:
  - → Specific files matching the search
    - » And other files supporting the findings
  - → String searches, keywords searches, and text string searches
  - → Internet-evidence: Web traffic analysis, chat logs, cache files, E-Mail, newsgroup activity, ICQ/Skype/… activity
  - → Graphic image analysis
  - → Ownership status of all files found
    - » Who of the users owned them/when were they created/accessed
  - → Techniques used to hide data or limit access to it
    - » Steganography, encryption, hidden attributes/partitions/streams
    - » Incorrect file names (e.g. JPEG files with ".bin" extension)
- Annex: Printouts, digital copies, documentation

Conclusions

- Obtaining some information from hard disks is easy
  - → Ensuring it is complete **and** usable in courts is difficult!
  - → There is only **a single chance** …
- A wide variety of hardware exists, which must be treated differently and contains various information
  - → Specialization is needed for in-depth investigation
- The huge amount of data on modern computers is a problem
  - → Try to reduce the scope of investigation
    - » Lists of "known good" files
  - → Automate examination
    - » Keyword searches, deleted file recreation etc.
- Expensive software needed
  - → Some investigation also possible with cheaper tools
  - → Open source software available partly



Questions?

Thank you for your attention!

Literature

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