Lock-in effects and security

Data sovereignty through avoiding data processing of digital assets under unknown conditions

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PICS seminar
University of Skövde
12 October 2023

Software Systems Research Group (SSRG) ...

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- The **mission** of the **Software Systems Research Group** (SSRG) is to **advance theory** and **practice** in socio-technical issues in the use and development of software systems
- *Goal:* **Societal impact *through* research outcomes**
- *SSRG's research activities are centred on investigation of a few (related) core **challenges** in the software systems domain through collaborative research projects (involving companies & other types of organisations):* **Data sovereignty**, **lock-in**, **interoperability**, and **long life-cycles** for **software systems** & **digital assets**
- *Focus*: Formats, Standards, Open Source Software, and Implementation of standards in software projects

Preamble – *On **lawful & appropriate** …*
*… **data processing** and **maintenance** of **digital assets***

- ‘Lawful and appropriate use of cloud-based globally provided Software-as-a-Service (SaaS) solutions by a public sector organisation (PSO) for **data processing** and maintenance of digital assets **presupposes** an **investigation of all relevant contract terms**.’ (Lundell et al., 2022b)

- The phrase **lawful and appropriate** ‘refers to **all the requirements imposed on each PSO** within the EU in accordance with **all applicable law and regulation**, and also the **principles of good administration** whether codified or not.’ (Lundell et al., 2022b)

***Challenges** in the **secondary software sector** …*

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- ‘support of Airbus A300 will last for 78 years’ (Lundell et al., 2011)
- ‘The program began in 1972 and the production stopped in 2007 [35 years] The support will last until 2050’ (Robert, 2007)



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Challenges in the secondary software sector …



- License lock-in,
- Cloud lock-in,
- Standard lock-in,
- Format lock-in,
- Product lock-in,
- Vendor lock-in,
- Trademark lock-in,
- Transform lock-in,
- Competence lock-in,
- Contract lock-in,
- …

*On **lock-in** …*

- ‘**Lock-in** is said to occur whenever a switching to a potential competitor product is made more difficult by external factors. These may be **human factors** such as familiarity with the system’s operation or user interface, development of internal work-arounds to tailor the system to a particular organisation’s needs, or the natural desire to remain with the existing system since its shortcomings are at least known and understood: the devil you know. Other forms of lock-in may be **technical**, such as the file formats and APIs that a particular system uses not being compatible with a potential future replacement system. **Lock-in** is **not unlawful *per se***, **but** it **may** in some circumstances **have legal consequences**. For example, lock-in imposed by a supplier may result in breaches of competition law, such as abuse of a dominant position.’ (Lundell et al., 2023b)

*On **lock-in effects** …*

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- ‘A major lock-in concern is **risk of dependence** (or over-dependence) **on one provider’s**, often proprietary, **service**.’

  (Hon et al., 2012)

- Research shows that **97%** (29 of 30) of the municipalities that were randomly selected for a study (amongst all 290 Swedish municipalities) **used** a specific SaaS solution (**Microsoft 365**)

  (Lundell et al., 2021b)

- Organisations that ‘seek to promote interoperability and the long-term maintenance of digital assets while avoiding lock-in must **engage with OSS projects that implement open** information and communications technology (**ICT**) **standards**’

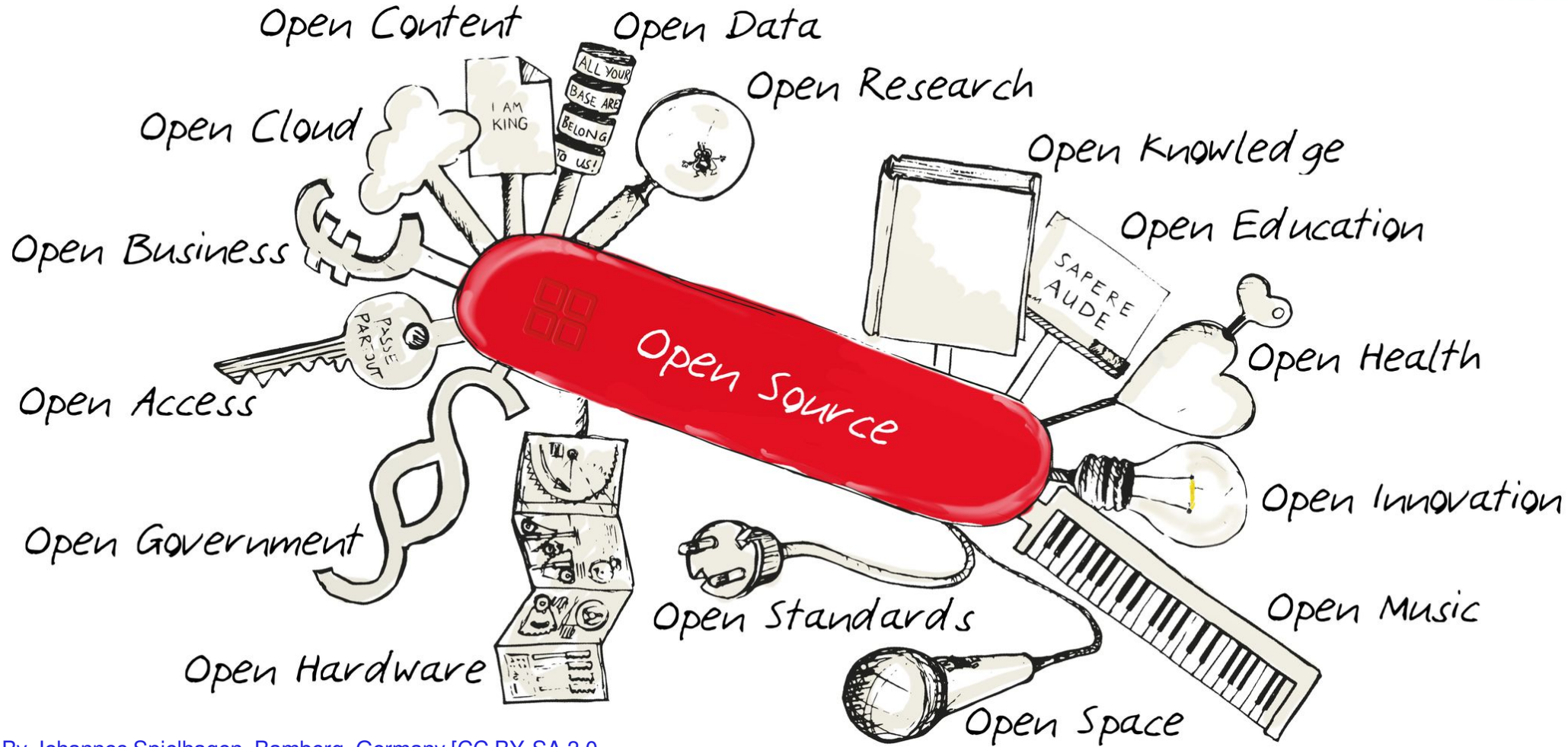
  (Lundell et al., 2022a)

*On **lock-in effects** – challenges concerning how …*
*… to establish and maintain **digital & data sovereignty**…*

- ‘In many industry domains, data are highly sensitive or needs to be protected. The current market structure risks dependency on international providers. Technical, economic and contractual obstacles in the path of a data migration to another infrastructure provider (so-called ‘**lock-in effects**’) constrain companies’ freedom in their operations – both in running their firms and in the event of political conflicts. In order that platforms and whole industries can continue to secure and expand their value creation, data infrastructure that strengthens the users’ **digital sovereignty** is necessary.’

(GAIA-X, 2019, p. 8)

Open Source – *and related concepts ...*



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Open Source Software

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- **Open Source Software** (**OSS**) is software which is provided under terms that **comply with the Open Source Definition** (OSD, https://opensource.org/osd) and made available under a **software licence** that has been **approved by the Open Source Initiative** (OSI, https://opensource.org)

- The Open Source Definition 'is a specification of what is permissible in a software license for that software to be referred to as Open Source' (Perens, 1999, p. 81)

- ' "Open Source" is the proper name of a campaign to promote the pre-existing concept of Free Software to business' (Perens, 2017)

Open Source Software – *significant impact ...*

- An **immediate economic effect** through **code reuse** and **effort reduction**: at least **114 Billion Euro** (31% of the software and services market) per year through direct savings, reduction in project failure and improvements in code maintenance cost

  (Daffara, 2012)

- 'It is estimated that **companies** located **in the EU invested around €1 billion in Open Source Software in 2018**, which brought about a **positive impact on the European economy of between €65 and €95 billion**. The study predicts that **an increase of 10 per cent in contributions to Open Source Software** code **would annually generate an additional 0.4 per cent to 0.6 per cent GDP**, as well as more than 600 additional ICT start-ups in the EU.'

  (Tynan, 2021)

Open Source Software – *security challenges ...*

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- ‘Our research found that, while open source software dominates the technology landscape, security measures and tooling in the software supply chain are lagging behind the pace of development.’ (Snyk, 2023)
- ‘The Log4Shell incident has had an impact on security behavior. Nearly two thirds of organizations implemented new tooling or new practices or increased the frequency of security scans in response to Log4Shell.’ (Snyk, 2023)
- ‘We tracked **TTF** [**time-to-fix**] over the past four complete calender years and found that the average TTF has steadily increased for proprietary applications and steadily decreased for open source applications since 2019. [...] [In 2022] **TTF for open source** applications fell **below** TTF for **proprietary** applications’ (Snyk, 2023)

OSS & *Cybersecurity strategies (1/2) ...*

- ‘Companies that make software must have the freedom to innovate, but they must also be held liable when they fail to live up to the duty of care they owe consumers, businesses, or critical infrastructure providers. **Responsibility** must be placed **on the stakeholders most capable of taking action to prevent bad outcomes**, **not on the end-users** that often bear the consequences of insecure software **nor on the open-source developer of a component that is integrated into a commercial product**. Doing so will drive the market to produce safer products and services while preserving innovation and the ability of startups and other small- and medium-sized businesses to compete against market leaders.’

(White House, 2023)

OSS & *Cybersecurity strategies (2/2) ...*

- ‘In partnership with the private sector and the open-source software community, the Federal Government will also continue to invest in the development of secure software, including memory-safe languages and software development techniques, frameworks, and testing tools.’ (White House, 2023)
- ‘As the European Cyber Resilience Act (CRA) is entering into the final legislative phase, it still has some needs arising from framing by the Commission or Parliament that result in breakage no matter how issues within its scope are “fixed”. [...] OSI [Open Source Initiative] still recommends the Cyber Resilience Act should exclude all activities prior to commercial deployment of software and clearly ensure that responsibility for CE marks does not rest with any actor who is not a direct commercial beneficiary of deployment.’ (OSI, 2023)

Open Standard

- A **standard** which conforms to the definition presented in the European Interoperability Framework (EIF) version 1.0 (EIF 1.0) constitutes an **open standard**
- A **format** provided under terms which conform to the definition of open standard (as defined in EIF 1.0) constitutes an **open format**
- An **open standard** (as defined in EIF 1.0) **can be implemented and distributed** under different licenses for closed source (proprietary) software and **under all licenses for OSS**, which are approved by Open Source Initiative (OSI)

Implementations of specifications of standards …
… may cause **standard & file format lock-in** …

- 'there are several problematic issues related to **clarity** and **detail** in **the specification** of the PDF format.'
- '**Implementations** may **cover a subset** of the features in the specification, and also features **beyond the specification**.'
- 'there are different kinds of **influences**, both **between different implementations** of a specification, and also **between a specification and its implementations**. … implementations of a specification are primarily influenced by the market leading implementation instead of the specification of a standard'
- '**patent issues** are perceived as **a concern** by contributors to open source projects implementing a specification of a standard'

(Gamalielsson & Lundell, 2013)

Implementations of specifications of standards …
… may cause **security issues** …

- ‘According to the Internet Security Threat Report, 2019 by Symantec, 48% of malicious email attachments were MS Office files in 2018.’ (Khan et al., 2021)
- ‘We are the first to provide an in-depth analysis of Office Open XML (OOXML) Signatures, the Ecma/ISO standard that all Microsoft Office applications use. Our analysis reveals major discrepancies between the structure of office documents and the way digital signatures are verified. These discrepancies lead to serious security flaws in the specification and in the implementation. As a result, we discovered five new attack classes. Each attack allows attackers to modify the content in signed documents, while the signatures are still displayed as valid.’ (Rohlmann et al., 2023)

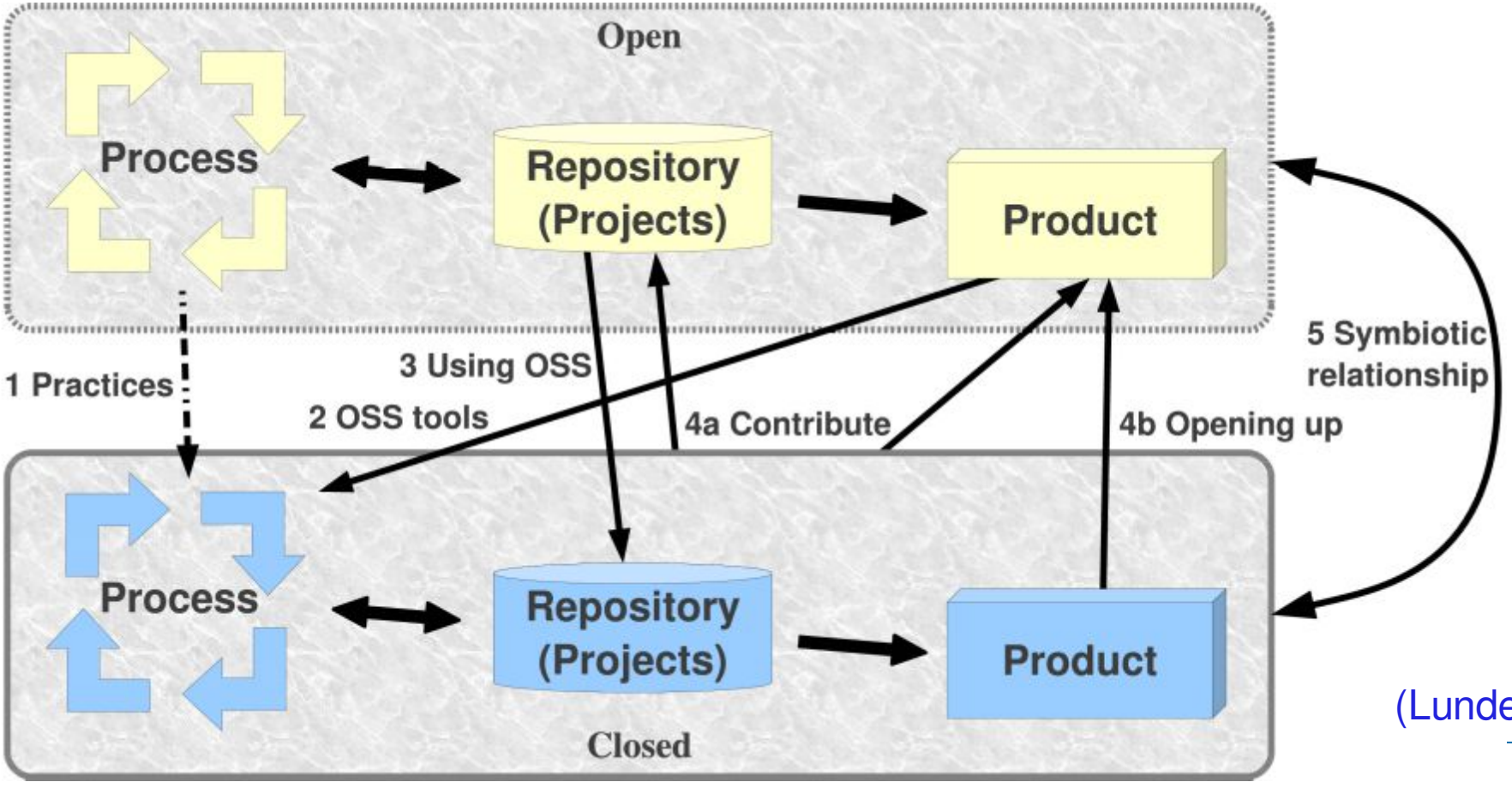
Implementations of specifications of standards ...
... may cause **format lock-in** & **licensing issues** ...

- The ‘HEVC standard constitutes an inherent part (as a normatively referenced standard via other standards) of the widely referenced file format ISO/IEC 29500 standard.’ (Lundell et al., 2023a)
- Contract ‘documents expresses that a customer which uses Microsoft 365 must obtain its own licences for HEVC:
  “Customer must obtain its own patent license(s) from any third party H.265/HEVC patent pools or rights holders before using Azure Media Services to encode or decode H.265/HEVC media.”’ (Lundell et al., 2023a)
- Finding ‘from the investigation of legal and licensing conditions for implementation and use of the HEVC standard show that it is impossible to obtain licences from apparent SEP holders that would allow for lawful use of the standard.’ (Lundell et al., 2023a)

Strategies *for how organisations can promote ...*
*... **sustainable development of software systems***

- **Sustainable** (healthy) **OSS projects** can effectively address challenges related to **lock-in** and **long life cycles** for **digital assets** and **software**
- **OSS projects** and associated work-practices can be utilised **beyond the software domain** (e.g. for development and maintenance of standards)
- An open standard which can be (and has been) implemented and **distributed** under **all OSS licences** (approved by the Open Source Initiative) by **OSS projects** (provided on open platforms) contribute to **interoperability** and to **minimise risks for different types of lock-in**

Different **strategies for how a company** ...
... can **engage** with **OSS projects** ...



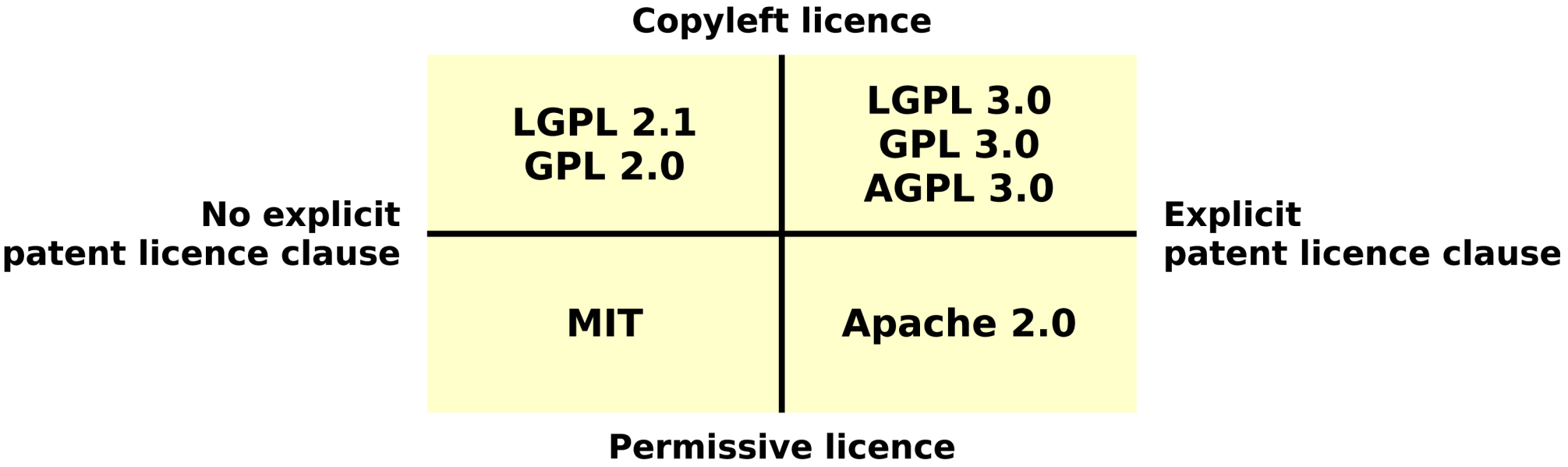
(Lundell et al., 2017)

OSS licences

- ‘A **copyleft license** is one that requires, as a condition of distribution (or making available) of software binaries, that the distributor make the corresponding source code available under the same licensing terms.’ (Meeker, 2020, p. 10)
- A study of 200 OSS projects providing widely-used software finds that 60% of all widely used OSS projects ‘are provided under the GPL-family of licences’ (Gamalielsson & Lundell, 2017)
- The **GPL copyleft licences ‘promote “fully symmetric” rights** among contributors (the most prominent of which being the Linux kernel)’ (Lundell et al., 2022a)

Different types of **OSS licences** …

… copyleft licences protect continued OSS project openness



(Lundell et al., 2022a)

See further (Lundell, 2020; Lundell et al., 2015, 2019)

Development & deployment of software applications

Development of software ...	Deployment of software ... Internal	Deployment of software ... External
Closed	e.g. **Microsoft Office 2019**	e.g. **Microsoft 365**
Open	e.g. **LibreOffice, Nextcloud**	e.g. **Nextcloud**

(Lundell et al., 2021a)

- Principle ways for **development** & **deployment** of **software applications** with illustrative examples in each category
- From the perspective of a procuring organisation, it should be noted that software applications provided under Open Source Software licences can be deployed both internally & externally

(Lundell et al., 2021a)

Assessing **lawful** & **appropriate** data processing ...

*… presupposes analysis of **formats** used for digital assets*

- ‘Investigations of several formats that providers of widely used cloud based SaaS solutions have (or claim to have) implemented show that it may be **impossible** to **clarify conditions** and **acquire all patent licences for standard essential patents** (and all necessary rights) **to allow for implementation in software**’ (Lundell et al., 2019, 2022b)
- We find that **no** public sector **organisation** ‘had investigated the need for acquiring all relevant contract terms and licences related to several **formats that would allow for data processing and maintenance** of **digital assets during** and **after use** of the [Microsoft 365] solution.’ (Lundell et al., 2022b)

Assessing **lawful** & **appropriate** data processing ...

*… presupposes analysis of all applicable **contract terms***

- Should a public sector organisation (PSO) 'have been **unable** to **identify** all **contract terms** governing the use of a specific SaaS solution it follows that it is **impossible to assess** if use of the specific solution is lawful and appropriate for the PSO' (Lundell et al., 2022b)

- We find that 'the vast majority of PSOs seem unaware of that conditions for use of the M365 solution change over time and that each PSO's **contract terms** for M365 allow for data processing through use of subsidiaries and subcontractors in numerous jurisdictions, including but not limited to China, Serbia, USA, and United Arab Emirates' (Lundell et al., 2022b)

Recommendations (1/3) ...

- ‘A procuring organisation needs to **express requirements for interoperability with open IT standards** [as defined by EIF 1.0] (instead of compatibility with a specific proprietary technology which is controlled by a single provider).’

(Lundell et al., 2021a)

- ‘Has the PSO obtained **all applicable licences** for the SaaS solution that provide the PSO **all technical abilities** and **all necessary rights** that allow for creation, processing, maintenance, and archiving of digital assets with available software (provided under open source software licences) after the PSO has ceased to use the SaaS solution (i.e. after exit)?’

(Lundell et al., 2021b)

Recommendations (2/3) ...

- Prior to a PSO's adoption and use of a software application the PSO needs to **ensure lawful and appropriate data processing** and **maintenance of its digital assets** *through* analysis of all **contract terms**; ensuring the **possibility of changed IT operation** (e.g. change from SaaS to on-prem); and identifying existence of an **effective exit strategy** which can be executed at short notice. The PSO needs to **obtain** the **complete technical specification** (including all normatively referenced specifications) and **all necessary rights** (incl. all licences for all SEPs) **for each format used**, and ensure **existence of OSS** (incl. OSS provided under the GPL-family) which correctly implements each format used (Lundell, 2022)

Recommendations (3/3) ...

- Use of software applications under **unknown conditions imposes risks** which each PSO should avoid (Lundell et al., 2022b)
- A potentially very effective ‘policy implication from the study would be to propose and **introduce, in law** or **policy, an obligation** for any provider offering a Software-as-a-Service solution to a public sector organisation, **to always provide all contract terms** at one and the same time in a cohesive format. A **corresponding obligation for a public sector organisation** in connection with adoption of such a solution to **ascertain that all contact terms have been obtained and filed**, would clarify the responsibilities of all parties involved.’

(Lundell et al., 2022b)

Summary – *Challenges for organisations ...*

- Each organisation (i.e. each company and each public sector organisation, PSO) needs to have **full control** of all **its digital assets** (data, documents, and other types of digital assets, such as the content in the organisation's databases) which **presupposes use of open formats** that have been **implemented in OSS to ensure lawful and suitable data processing and maintenance of** the organisation's **digital assets over** very **long life-cycles** (Lundell, 2022)
- Has any PSO obtained and filed all applicable contract terms prior to the PSO's use of a globally provided SaaS solution in order to **avoid data processing and maintenance of its digital assets under unknown conditions**?

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