SaaS vs. IaaS vs. On-premise
Survey on Adoption Factors

Bachelor of Science Thesis in Software Engineering and Management

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Abstract—**Companies acquire software or make their own software depending on their resources and demands. As external software, Software as a Service (SaaS), has grown in breadth and depth, they have become increasingly popular. On-premise software can also still be favorable as it may be more secure, private or economical. Researchers have invested considerable effort in the study of companies adopting SaaS for enterprise resource planning (ERP) or customer relationship management (CRM) systems. There is little research on adopting SaaS for software other than ERP or CRM. This study aims to understand the factors a business considers when deciding to adopt SaaS. Furthermore, the study aims to ask relevant questions to the business in the current political climate with companies collecting more personal data than ever before. On May 25, 2018 the General Data Protection Regulation (GDPR) came into force in the European Union (EU) after being passed two years prior. This is a law on data protection and privacy for all individuals within the EU. The law has many implications for companies that collect personal data and, as a result, the software industry has had to reassess their data holding methods. The study seeks to clarify how companies will decide on SaaS regarding security and privacy with GDPR enacted. We conducted an online survey of 35 software professionals and observed there are some factors that affect whether a company will adopt SaaS solutions or on-premise solutions and GDPR is an influencing factor.**

Keywords-**CRM, ERP, decision support, GDPR, IaaS, operation modes, SaaS**

I. INTRODUCTION

Cloud computing is used by 70% of businesses around the world [1] and annual global spending on cloud services is expected to increase by a 19.4% compound annual growth rate (CAGR) by 2019 going from about $70 billion in 2015 to more than $141 billion in 2019 [2]. Software as a Service (SaaS) is the largest category of cloud computing consisting of over two-thirds of the spending annually and Infrastructure as a Service (IaaS) is projected to grow at a faster rate than SaaS with a five-year CAGR of 27.0% [2]. Market research firm Ovum notes that between 2015 and 2017 enterprise cloud spending increased, with 50% of respondents reporting an increase in SaaS spending, 46% increasing spending on IaaS, and 47% increasing spending on PaaS [1]. We define the following deployment methods:

- SaaS: Software offered as a service, incurring in a recurrent cost, and fully managed by the service provider.

TABLE I
DIFFERENCES BETWEEN METHODS

On-Premise	IaaS	SaaS
Applications	Applications	**Applications**
Data	Data	**Data**
Runtime	Runtime	**Runtime**
Middleware	Middleware	**Middleware**
OS	OS	**OS**
Virtualization	**Virtualization**	**Virtualization**
Servers	**Servers**	**Servers**
Storage	**Storage**	**Storage**
Networking	**Networking**	**Networking**

* Bold text indicating outsourced layers.

- IaaS: Software deployed to a cloud infrastructure service, incurring in a separate recurrent cost for infrastructure, licensing costs for the software itself, and managed by the organization or a third-party contracted by the organization.
- On-premise: Software deployed to infrastructure owned by the organization, and managed by the organization or a third-party contracted by the organization.

Table [1] shows whether the business manages a feature for an on-premise, IaaS, and SaaS software. The bold-text features indicate what the company does not need to be responsible for, i.e. the on-premise software requires that the company must be in charge of all elements of the software deployment.

Companies that offer cloud computing services are attractive as they can be cost effective, scalable, and adhere to data protection policy, provide support, among many other factors. Researchers often focus on business software such as Enterprise Resource Planning (ERP) applications [3]–[6] or Customer Relationship Management (CRM) applications [7], [8], or address adoption cost structure [8], [9]. ERP is a business process management software that aims to connect and integrate the company's resources, financial, supply chain and operations. CRM allows businesses to manage relationships with customers and the data and information associated with them. Non-ERP and non-CRM software include: mobile apps storage and data, application development and testing, custom/industry-specific applications, marketing/social media sites, commercially licensed database, web server, online

presence, storage backup, collaboration, business productivity tools, email and messaging, etc. Thus, this study aims to understand not only SaaS adoption for ERP and CRM software but for any kind of business software.

CRM and ERP solutions are similar software solutions focused on operational efficiency and financial performance. Research is generally focused on these two solutions because CRM and ERP solutions are increasingly popular with compound annual growth rates of 7.2% and 12.3%, respectively [10], [11].

Another benefit of an enterprise choosing SaaS is their compliance with regulations as they aim to appeal to as many businesses as possible. In 2016, there was a significant increase in companies considering or already choosing SaaS for ERP which coincides with EU's new data law [12]. GDPR was adopted by the European Union on April 14, 2016 and came into force on May 25, 2018. GDPR replaces the Data Protection Directive 95/46/EC ("Directive") and gives more data subject rights and privileges. Some responsibilities GDPR enforces include that a company will inform regulators of a data breach, must be able to securely protect any subscriber's information, provide any of the information the company has collected about a subscriber and delete the information upon request, among other guidelines. Most importantly, if any subscriber of the business lives in an EU country, then the business must be GDPR compliant. Thus the majority of multinational companies must become GDPR compliant since even if one customer is in the EU, the company must adhere to the law. The GDPR guidelines are numerous and comprehensive which makes it easier for software companies to choose GDPR-compliant SaaS compared to overhauling current business software or ensuring new software is legal.

Therefore, the goal of this study is *to understand the motivations for choosing a SaaS vs. IaaS vs. on-premise software solution for all business software in the current political climate.* This understanding can help businesses identify key factors when choosing a software and how GDPR will have significant effects on the future and success of a company's software implementation effort. To address this goal, we contacted as many people we knew to answer the survey, and purchased LinkedIn and Facebook advertisements to gather survey responses. The survey received 35 responses from software professionals from a variety of organizations. We analyzed the Likert scales and open-ended responses to understand which factors were statistically significant. The major findings of this study are:

- Statistically significant factors to decide a deployment method.
- A better understanding of software professionals' motivation and hindrances in adopting one methodology over another.
- The implication of a GDPR future and its effect on the forward-thinking software industry.

The rest of the paper is organized as follows. Section II describes the research questions. Section III elaborates on the research background for each research question. Section IV presents the study methodology. Section V characterizes the participants of the study and provides the survey results. Section VI discusses the implications of the results. Section VII addresses the threats to validity. Finally, Section VIII concludes the paper.

II. RESEARCH QUESTIONS

These are the specific research questions which help formulate the survey and help answer our research goal.

RQ1: What are the top factors considered when deciding for a SaaS vs. IaaS vs. on-premise solution for business software applications?

We looked at some factors that other research has pointed out as determinants to choosing a deployment solution and explained the research and factors in Section III (Background) [1], [6], [8], [12]–[15]. We derive our survey's adoption factors from existing research, with special focus on existing surveys and the factors they mention.

RQ2: In what factor does each deployment method excel?

We examine each factor and how effective it is in each deployment method. We inspect each deployment method's strengths and weaknesses for each factor in the background section.

RQ3: Which adoption factors are related with enacted privacy legislation in Europe (GDPR)?

Since GDPR is a new law that has a wide-reaching impact on all companies as we have explained in the introduction, we wanted to investigate how the legislation impacts the factors companies consider when choosing a deployment method. In the following section we explain GDPR's impact on each factor.

III. BACKGROUND

When looking at what factors determine how a company will choose its software deployment there are many components to consider. We have picked six factors to ask about in our survey. Published literature also offers insights on the influence that organization size and type of industry may have when deciding on a deployment method [6], [16], but we do not consider organization characteristics in this study.

Upfront and recurrent costs - When determining how to plan for future costs, there are several factors to consider.

- *License vs. subscription*: Generally one pays for subscriptions for a SaaS system. Vendors often have discounts for larger time commitments or upfront payment. Similarly, most on-premise systems are sold through licenses, so it is typically a one-time upfront cost. When buying licenses, one needs to consider how many years until a major upgrade and additional license costs per year depending on how the company grows.

- *Installation vs. Set-Up*: Although there is no physical set up needed, most SaaS vendors of larger systems charge a set-up fee for the work they must do to implement the system. In on-premise systems, one must also consider the cost of installing the software, configuring the database, and ensuring the software works on all needed computers. It is important to consider the cost of a major upgrade whereas in a SaaS system the upgrade cost would usually be free as it is included in the subscription.
- *Data Migration*: When choosing a new software system, one must migrate the data, whether that be from CSV files or physical data. Depending on the system there will be different data migration costs. Some SaaS vendors will charge for these services.
- *Maintenance vs. Support*: Usually SaaS vendors include support fees into their subscription costs but will offer premium support packages. On-premise models generally rely on annual maintenance contracts which include updates, bug patches, and support. The contract prices tend to be from 16-22%. Often companies will increase their support price over time, e.g. Oracle starts with a 17% maintenance contract fee and increases a percentage every year [13].
- *Hardware*: Since SaaS vendors provide hosting, hardware does not need consideration. Although some companies still invest in servers and hardware for backup of using a SaaS system. On-premise systems will require hardware which could include app servers, database servers, company-use computers, and networking infrastructure. It is important to keep in mind the hardware life expectancy and additional hardware costs per year.

Upfront and recurrent costs with GDPR - As employers can choose whether or not to pick an external service that is compliant or go through their existing software code base to ensure it is compliant. The business needs to determine whether it is ready to delegate current employees to manage this or hire trained officials to refactor their code base.

Ease of upgrades - According to Aberdeen Research Group, an often-cited reason organizations are becoming more receptive to purchasing SaaS solutions is "there are no upgrade costs because upgrades are handled automatically" [16]. The study found that it was the second most important positive factor about SaaS with 52% of respondents agreeing with "reduces the cost and effort of upgrades". One must decide whether using in-house resources to work on upgrades is worth the overall cost especially when having software that employees may need to learn how to use or having many different software systems that need training costs and company resources. Customizations are cited as a reoccurring barrier to implementing updates in on-premise systems [3], "customizations have to be recreated or worked around which introduce unpalatable complexities, risks, and costs".

Ease of implementation - Usability is how easy it is for the company to adapt to the new software system. Some things to consider are training, access to documentation, and data availability of the software. Training can involve vendors' training

centers, bringing trainers on-site, participating in webinars, or creating custom courses and documentation. Interviewing 20 experts the study found that 17 experts expressed that "system usability was an important factor to adopt ERP in a SaaS delivery model" [7]. Five experts expressed the concern of an intuitive and simple to use interface. All participants stated the main reasons behind adopting SaaS is "the risk of a possible bad implementation shifts from the customer to the provider" in line with traditional outsourcing of IT.

Security and privacy - Security and privacy is integral to deciding on a software system and increasingly so [3], [5], [7], [8]. GDPR coming into force has given rise to private litigation against small-, mid- and large-sized organizations, which can be costly if not financially devastating. The first day GDPR was enforced, Facebook and Google were hit with lawsuits claiming $4.6 billion and $4.4 billion in fines, respectively, from an Austrian law firm for failure to comply with GDPR. SaaS systems are often GDPR compliant which allows companies to forgo the effort in ensuring their software is GDPR compliant.

In this context, the company now has to look at how it is handling EU citizens' data and will need to ensure extra precaution for any data that might be in the cloud or leased out or sold to another company. Although the precursor to GDPR was the Data Protection Act (DPA), GDPR is much more comprehensive in its guidelines, and introduces a higher risk in the case of non compliance.

Availability and reliability - Cloud computing is not always available nor reliable. In May 2016, one of Salesforce's (the largest SaaS provider) largest data center NA14 in Silicon Valley suffered a downtime of 12 hours and subsequently, failed to migrate to a new center thus losing a substantial amount of data [17]. Larger server rooms are fire-susceptible as they get extremely hot and need well-ventilated rooms and cooling systems to operate. Thus, it is imperative that a company investigate what SaaS providers are most reliable and the trade-off of operating data centers oneself, support teams, and reliable software and hardware.

Performance and scalability - Performance may suffer with a SaaS service if the service is too far away or not enough compute resources which can cause latency and packet loss [18]. Similarly, performance can be negatively affected in on-premise systems when there is not enough compute resources or if they are engineered poorly. SaaS offers scalability incomparable to on-premise systems as most SaaS providers have options to move up in compute power or data storage in an instant.

IV. METHODOLOGY

Focusing on the research questions we created a survey as our system. The data collection involved interviews and online surveys of software engineering professionals. The factors determining whether an enterprise adopts SaaS vs. IaaS vs. on-premise are based on existing literature as elaborated in the previous section.

The factors are:

- Upfront and recurrent costs
- Easy to upgrade
- Ease of implementation
- Security and privacy
- Availability and reliability
- Performance and scalability

The questionnaire has quantitative and qualitative questions which include: (i) how important each factor is when deciding on a deployment method, (ii) which deployment is best at each factor, and (iii) whether the respondent's organization is ready for GDPR compliance. There are several multiple choice questions with choices derived from existing literature for each of the aspects to be addressed in the questionnaire (i-iii). Open-ended questions will be included for respondents to address aspects not covered by the question choices, and to enrich the final analysis by quoting respondents, adding qualitative input to the analysis section. This survey asks the following questions:

A. Question 1

When deciding on a deployment method for a business application, how important is each of these factors?

Value	-2	-1	0	1	2
Factor 1			Select one.		
Factor 2			Select one.		
Factor N			Select one.		

Where values are mapped to a Likert scale as follows:

-2 Not important at all
-1 Not very important
 0 Neutral
 1 Somewhat important
 2 Very important

The complementary open-ended question is "Which are the most important factor(s) and why are they the most important?". The statistical analysis (i) calculates the 1st, 2nd,..., Nth most frequent option selected for each factor, and (ii) generates a box plot displaying median, 1st and 3rd quartiles for each factor in order to visualize how factors compare with each other.

B. Question 2

Which deployment approach(es) are better at each of these factors?

	SaaS	IaaS	On-premise
Factor 1		Select one or two.	
Factor 2		Select one or two.	
Factor N		Select one or two.	

The complementary open-ended question is "What is your preferred deployment method(s) and, in your view, in what ways does it excel?". We analyzed the question by calculating the 1st, 2nd, N most frequent deployment method selected for each factor.

C. Question 3

Is your organization ready for GDPR compliance?

Yes	No
Select one.	

The complementary open-ended question is "Elaborate. Have you been in contact with a vendor or consultant specialized on GDPR? What guarantees does your organization have to view itself as GDPR-compliant?".

In order to connect GDPR and deployment method adoption factors, we first define *two groups* according to the answers for *Question 3*: (A) respondents that are ready for GDPR, and (B) respondents who are not, then calculate whether there is a statistically significant difference between the two groups in the way each factor is ranked on *Question 1*.

In order to quantify the statistical significance of the question we implemented two tests.

Test 1: Two-Tailed Mann Whitney U Test

The hypotheses being tested in regards to the importance of each adoption factor are the following: The null hypothesis is that there is no statistically significant difference, in the distribution of the answers to the Likert scale [-2, 2] representing importance assigned to each specific factor, between respondents from (a) GDPR-compliant organizations, and (b) non GDPR-compliant organizations. The alternative hypothesis is that there is a statistically significant difference.

In order to test this hypothesis we use a 2-tailed Mann Whitney U Test with an alpha level of 0.05. The assumptions of the test are (i) the observations from both groups are independent of each other, and (ii) the type of data is ordinal. We can say that assumption (i) is true since subjects were randomly selected, and (ii) is true due to the inherent order of Likert scales.

Test 2: One-Tailed Mann Whitney U Test

For each factor where the first test resulted in statistically significant evidence to reject the null hypothesis, we perform two additional tests, a 1-tailed Mann Whitney U Test in each direction with an alpha level of 0.025.

- **Upper-tailed test:** The null hypothesis is that there is no statistically significant difference, and the alternative hypothesis is that there is a statistically significant difference in the "greater than" direction.
- **Lower-tailed test:** The null hypothesis is that there is no statistically significant difference, and the alternative hypothesis is that there is a statistically significant difference in the "less than" direction.

V. RESULTS

To provide context for the results described in this section, what follows is the demographic information characterizing the respondents that participated in the survey, as well as the organizations they represent.
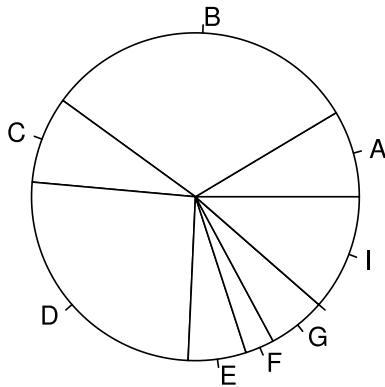
Organization size

Fig. 1.   Respondents by organization size

TABLE II
RESPONDENTS BY ORGANIZATION SIZE

Option	Description	Count	Percentage
A	Self-employed	3	8.57
B	1-10 employees	11	31.43
C	11-50 employees	3	8.57
D	51-200 employees	9	25.71
E	201-500 employees	2	5.71
F	501-1000 employees	1	2.86
G	1001-5000 employees	2	5.71
H	5001-10,000 employees	0	0.00
I	10,001+ employees	4	11.43

The most common organization size among respondents is 1-10 employees (31.43%). 51-200 employees is the second most common (25.71%), and 10,001+ employees third most common (11.43%). Small-, medium-, and large-sized organizations are all represented in the study.
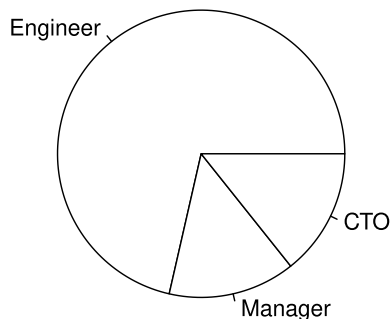
Role in the organization

Fig. 2.   Respondents by role in the organization

25 of the respondents (71.42%) are software engineers, developers. 5 (14.29%) are managers, directors. 5 (14.29%) are chief technology officers.
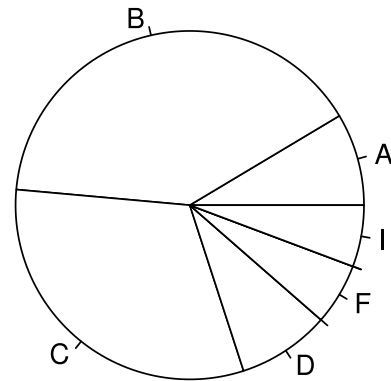
Engineering effort size

Fig. 3.   Respondents by size of the engineering effort

TABLE III
RESPONDENTS BY ENGINEERING EFFORT SIZE

Option	Description	Count	Percentage
A	Self-employed	3	8.57
B	1-10 employees	14	40.00
C	11-50 employees	11	31.43
D	51-200 employees	3	8.57
E	201-500 employees	0	0.00
F	501-1000 employees	2	5.71
G	1001-5000 employees	0	0.00
H	5001-10,000 employees	0	0.00
I	10,001+ employees	2	5.71

The majority of the respondents (80%) are part of an engineering effort of less than 50 employees, and the most common size of engineering effort in the survey is 1-10 employees (40%).
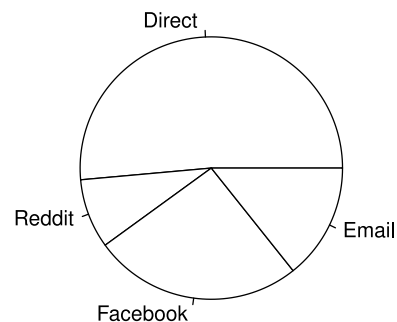
Acquisition channels

Fig. 4.   Respondents by acquisition channel

The 35 respondents were directed to the survey via multiple acquisition channels: 18 via direct referral (51.43%), 9 via Facebook (25.71%), 5 via Email (14.29%), and 3 via Reddit (8.57%).

In this section results are presented in connection with each research question formulated in Section II.

RQ1: What are the top factors considered when deciding for a SaaS vs. IaaS vs. on-premise solution for business software applications?

To help answer this question we asked respondents to rank each factor on a Likert scale from (-2) Not important at all, to (2) Very important, see Section IV (Methodology). What follows is the frequency distribution (indicating mode for each factor), and box plot (indicating median and quartiles). We use the median to represent the central tendency for each factor.
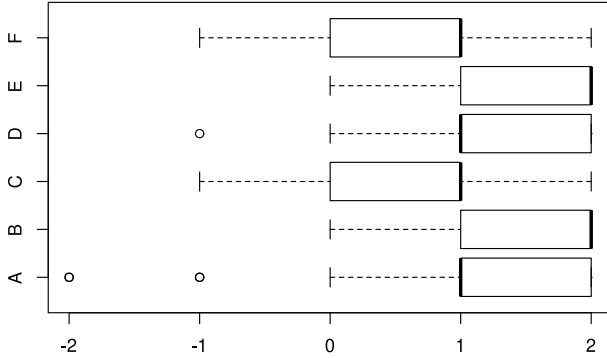

Fig. 5. Box plot of answers to *Question 1* by factor

TABLE IV
FREQUENCY DISTRIBUTION OF ANSWERS TO *Question 1* BY FACTOR

Opt.	Description	-2	-1	0	1	2
A	Upfront and recurrent costs	2	2	3	15	13
B	Availability and reliability	0	0	1	13	21
C	Ease of implementation	0	2	10	16	7
D	Performance and scalability	0	1	7	15	12
E	Security and privacy	0	0	7	10	18
F	Easy to upgrade	0	6	5	21	3

TABLE V
STATISTICAL SUMMARY OF ANSWERS TO *Question 1* BY FACTOR

Opt.	Description	min	q1	q2	q3	max
A	Upfront and recurrent costs	-2	1	1	2	2
B	Availability and reliability	0	1	2	2	2
C	Ease of implementation	-1	0	1	1	2
D	Performance and scalability	-1	1	1	2	2
E	Security and privacy	0	1	2	2	2
F	Easy to upgrade	-1	0	1	1	2

q1 = first quartile, q2 = median, q3 = third quartile.

From these observations, we can say that factors *(B) Availability and reliability* and *(E) Security and privacy* are perceived to be the most influential factors when deciding on a deployment method. These factors presented the highest median (2 = *Very important*), as well as the highest mode (2 = *Very important*). The implications of these observations are further discussed in Section VI (Discussion).

RQ2: In what factor does each deployment method excel?

To answer this question we asked respondents which deployment methods perform better at each specific factor. What follows are the results for each factor.

TABLE VI
ANSWERS TO *Question 2* BY FACTOR

Opt.	SaaS	IaaS	On-premise
A	18 (51.43%)	19 (54.29%)	17 (48.57%)
B	25 (71.43%)	15 (42.86%)	9 (25.71%)
C	28 (80.00%)	2 (5.71%)	12 (34.29%)
D	24 (68.57%)	5 (14.29%)	12 (34.29%)
E	8 (22.86%)	10 (28.57%)	29 (82.86%)
F	28 (80.00%)	8 (22.86%)	14 (40.00%)

IaaS deployments were seen as the best option when it comes to *Upfront and recurrent costs*, whereas *on-premise* deployments were seen as the best option in terms of *Security and privacy*. *SaaS* dominated all other factors, and is perceived to be the go-to option for its *Availability and reliability*, *Ease of implementation*, *Performance and scalability*, and the fact that it is *Easy to upgrade*.

RQ3: Which adoption factors are related with enacted privacy legislation in Europe (GDPR)?

14 (40%) of the respondents represented companies that were GDPR compliant, 21 (60%) of the respondents represented companies that were *not* GDPR compliant. In order to answer this research question we compare answers to *Question 1* by respondents from (i) GDPR compliant organizations, and (ii) non GDPR compliant organizations, following the statistical test described in Section IV (Methodology).

T1: Two-Tailed Mann Whitney U Test (=)
- H_0 Importance(GDPR) = Importance(non-GDPR)
- H_1 Importance(GDPR) $\neq$ Importance(non-GDPR)
- $\alpha = 0.05$

T2.1: One-Tailed Mann Whitney U Test (>)
- H_0 Importance(GDPR) = Importance(non-GDPR)
- H_1 Importance(GDPR) > Importance(non-GDPR)
- $\alpha = 0.025$

T2.2: One-Tailed Mann Whitney U Test (<)
- H_0 Importance(GDPR) = Importance(non-GDPR)
- H_1 Importance(GDPR) < Importance(non-GDPR)
- $\alpha = 0.025$

TABLE VII
p-value OBTAINED FOR EACH TEST BY FACTOR

Opt.	T1 (=)	T2.1 (>)	T2.2 (<)
A	0.0451	0.02254	0.9793
B	0.6231	N/A	
C	0.2798	N/A	
D	0.2719	N/A	
E	0.0212	0.01057	0.9904
F	0.0024	0.00119	0.9999

From these results we derive that there is statistically significant evidence to say that: (i) GDPR compliant organizations, and (ii) non GDPR compliant organizations, view

specific factors differently. *(A) Upfront and recurrent costs*, *(E) Security and privacy*, and being *(F) Easy to upgrade*, were perceived to be *more important* by GDPR compliant organizations. How each factor is connected with GDPR is further elaborated in the next section.

VI. DISCUSSION

RQ1: What are the top factors considered when deciding for a SaaS vs. IaaS vs. on-premise solution for business software applications?

In the survey results, *Availability and reliability*, and *Security and privacy* are perceived to be the most influential factors when deciding on a deployment method.

An open-ended answer related availability and reliability to compliance with organizational procedures: "Availability is a big deal because there is strict reporting to the parent company, this has to follow a timeline (...)" mentioned a System Developer, "(...) Reporting is done in a short timeframe towards the end of the month, the site has to be up".

Whereas security and privacy was related to requirements in an organization where confidentiality is a top priority: "it's super confidential, [upfront and recurrent] costs are not as important for the software itself as the security and privacy of the software." said a Software Engineer.

Though derived from the organizations' own specific requirements, both factors *(B) Availability and reliability* and *(E) Security and privacy* are closely related within the domain of *Data Governance*, which is defined as *"the process by which a company manages the quantity, consistency, usability, security and availability of data"* Cohen (2016). A case study from as early as 2007 summarizes the need for data governance: data governance programs should be driven by the business, since data is used by businesses to make decisions [19], so it seems logical that these factors would be important for business applications, which are the focus of this study. *"(...) the business should control the data, determine who can access the data and the context that it should be used"* [19].

Excluding the top two factors, with the highest third quartiles, *Performance and scalability*, and *Upfront and recurrent costs* were ranked as second most important. These factors were not unknown to respondents, as a Product Manager put it "Any time a software solution is being added or implemented, it's a delicate balance between cost of implementation and expected result and impact to overall bottom-line. The work required to implement any type of software solution should always pay dividends later on, so it's important to have a clear expectation of what the end-impact should be (i.e. how much time will it save operations and developers down the line) and this should be considered as part of the overall consideration and evaluation of the solution down the line".

RQ2: In what factor does each deployment method excel?

SaaS was seen as the top performer in four out of the six adoption factors, which helps us explain why SaaS is the largest category of cloud computing spending, consisting of over two-thirds of spending annually [2].

A recurrent theme in open-ended answers by respondents with preference for SaaS and IaaS was avoiding hardware maintenance. "IaaS deployment is preferred for me, as it's the best of both worlds. You get an out-of-the-box component or solution from a SaaS perspective, but you have inherent control of the functionalities and broader project scope" said a Product Manager. "SaaS is the best one as my company doesn't need to deal with infrastructure nor keeping up the servers." a back-end Software Developer. However, this may come at the expense of security and privacy, which was seen as the top factor for adopting on-premise deployments.

RQ3: Which adoption factors are related with enacted privacy legislation in Europe (GDPR)?

Three factors were seen as more important by GDPR compliant organizations: *(A) Upfront and recurrent costs*, *(E) Security and privacy*, and being *(F) Easy to upgrade*.

Upfront and recurrent costs: GDPR compliance, like any other form of regulatory compliance, requires dedicating resources and therefore has an impact on an organization's budget. The *Cost of Compliance 2018* report by Thomson Reuters highlights the implementation of GDPR as a key concern when it comes to regulatory compliance, and as much as 61% of firms are expecting an increase in their total compliance budget in 2018 [20].

Furthermore, the enactment of GDPR adds to the risk equation in the form of fines of up to 20 million euros or 4% of global revenue, whichever is higher (EUR-Lex, 2018).

Security and privacy: GDPR targets the processing of EU citizens' data. In particular, it is an attempt to secure privacy and control of the data by service providers and end-users. It seems logical that this factor would be considered more important by GDPR compliant organizations when it comes to deciding on a deployment method.

Easy to upgrade: Open-ended answers pointed out to specific *functional* requirements necessary for GDPR compliance. This implies that becoming compliant requires updating or implementing new features, in other words: upgrades. These specific areas were mentioned:

- Cookie preferences
- Data subject access requests
- Consent opt-in dialogs
- Terms of use and privacy notices

This leads us to believe that regulatory compliance has an influence when it comes to deciding on a deployment method in terms of how easy the service makes it to become compliant by upgrading. However, the top performer for *Upfront and recurrent costs* was IaaS, for *Security and privacy* was on-premise, and for *Easy to upgrade* was SaaS. In this context, and considering that GDPR compliant organizations see a higher concern around three factors not strictly connected with a specific deployment method, we are not inclined to believe that GDPR presents an opportunity for a specific deployment method.

VII. Threats to Validity

This section describes the internal, external, and construct validity threats of the study.

A. Internal Threats

In terms of *selection*, software engineering professionals with decision making power were not as easy to reach and, given the demographic data collected, do not conform a portion of the sample as large as it may have been desirable. However, we do not have any reason to believe that professionals without software engineering knowledge answered the survey, due to the technical nature of the questionnaire.

B. External Threats

It is possible that some of the respondents from non GDPR compliant organizations were, in fact, from GDPR compliant organizations. It is possible that they were not aware that their organizations were implicitly compliant by not handling personally identifiable data in the first place. However, most organizations handle personal data in one way or another.

C. Construct Threats

Respondents may misunderstand the intent of the questions in the survey. To mitigate this threat, we designed the questionnaire in an iterative fashion, involving software engineering and market research professionals in the process.

VIII. Conclusion

In this study we surveyed software engineering professionals to understand their view when it comes to deciding on a deployment method (SaaS vs. IaaS vs. on-premise), and the factors that influence their decision. We looked at existing literature to derive the six most relevant factors: (i) Upfront and recurrent costs, (ii) Availability and reliability, (iii) Ease of implementation, (iv) Performance and scalability, (v) Security and privacy, and (vi) Ease of upgrades.

We found that, in respondents' own view, the two most important factors influencing the choice of a deployment method were: *availability and reliability*, and *security and privacy*. We also observed that SaaS was seen as the best performer in four out of the six factors, except for *upfront and recurrent costs* where *IaaS* was seen more favorably, and for *security and privacy* where *on-premise* deployments were seen as the best option.

Additionally, we investigated the influence that GDPR may have on the choice of deployment method, and found that *upfront and recurrent costs*, *security and privacy*, and *ease of upgrades* were perceived to be more important by GDPR compliant organizations. However, we are not inclined to believe that GDPR presents an opportunity for any of the deployment methods in particular.

References

[1] R. Illsley, "2018 trends to watch: Cloud computing," Enterprise Decision Maker, Ovum, white paper, October 2017.

[2] R. L. Villars, L. Carvalho, D. Mohan, and F. Della Rosa, "2018 worldwide public cloud services competitive landscape: Concentration, stability, or diversification?" IDC, white paper, May 2018.

[3] B. Johansson and P. Ruivo, "Exploring factors for adopting erp as saas," *Procedia Technology*, vol. 9, pp. 94–99, 2013.

[4] J. Duan, P. Faker, A. Fesak, and T. Stuart, "Benefits and drawbacks of cloud-based versus traditional erp systems," *Proceedings of the 2012-13 course on Advanced Resource Planning*, 2013.

[5] J. Gross, "Saas versus on-premise erp," Ziff Davis Inc, white paper, 2012.

[6] B. Link, "Considering the company's characteristics in choosing between saas vs. on-premise-erps." in *Wirtschaftsinformatik*, 2013, p. 17.

[7] T. Ratametha and M. Veeragandham, *CRM: Software as a Service versus Onpremise – benefits and drawbacks*. LAP Lambert Academic Publishing, August 2009.

[8] S. Bibi, D. Katsaros, and P. Bozanis, "Business application acquisition: On-premise or saas-based solutions?" *IEEE software*, vol. 29, no. 3, pp. 86–93, 2012.

[9] L. Herbert and J. Erickson, "The roi of software-as-a-service," *Forrester Research*, 2009.

[10] F. Burnson, "Enterprise resource planning software buyer report," Software Advice, 2015.

[11] L. Columbus, "2015 gartner crm market share analysis shows salesforce in the lead, growing faster than market," 2016.

[12] B. A. Safari, "Intangible privacy rights: How europe's gdpr will set a new global standard for personal data protection," *Seton Hall L. Rev.*, vol. 47, p. 809, 2016.

[13] M. H. Weier, "Software maintenance fees: Time for this model to change," *Information Week, Available at: http://www.informationweek.com/news/software/erp/showArticle.jhtml*, 2009.

[14] A. Ferrari, C. Rossignoli, and L. Mola, "Organizational factors as determinants of saas adoption," in *Information systems: crossroads for organization, management, accounting and engineering*. Springer, 2012, pp. 61–66.

[15] M. Xin and N. Levina, "Software-as-a-service model: Elaborating client-side adoption factors," in *International Conference on Information Systems (ICIS)*, 2008.

[16] N. Castellina, "Saas and cloud erp trends, observations, and performance 2011," *Analyst Inside*, 2011.

[17] S. Sharwood, "Storage array firmware bug caused salesforce data loss," The Register, May 2016.

[18] N. Leavitt, "Is cloud computing really ready for prime time?" *Computer, from IEEE Computer Society*, no. 1, pp. 15–20, 2009.

[19] L. K. Cheong and V. Chang, "The need for data governance: a case study," *ACIS 2007 Proceedings*, p. 100, 2007.

[20] S. English and S. Hammond, "Cost of compliance 2018," *Thomson Reuters Accelus*, 2018.

Appendix I: Questionnaire

Page 1

Demographic Q1 - What is the size of the organization that you work with?

Hint: If you are a consultant working on a full-time assignment at another company, answer about that company instead.

Option	Description
A	Self-employed
B	1-10 employees
C	11-50 employees
D	51-200 employees
E	201-500 employees
F	501-1000 employees
G	1001-5000 employees
H	5001-10,000 employees
I	10,001+ employees

Demographic Q2 - How many people in the organization are part of the software engineering and development effort?

Hint: Number of software developers, software engineers, testers, reliability and quality engineers, project managers, product and technology managers, and senior managers or executive leaders with an active role in the software development process.

Same options as Demograhic Q1.

Demographic Q3 - What is your role in the organization?

Hint: Your professional title or position (i.e. Software Engineer).

This is a free text question.

Page 2

Introduction

Think about a recent time when your organization had to adopt a software solution. Any kind of software solution:

- Accounting
- Business intelligence
- Invoicing
- Mailing
- Messaging
- Monitoring
- Payroll management
- Project management
- etc.

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Context of the Survey

Whatever the kind of software solution you are thinking of, with the ubiquity of the cloud, every organization faces a decision: whether to go for (1) a fully managed SaaS solution, (2) an IaaS solution, or (3) an on-premise solution.

- (1) SaaS: Software acquired as a service, incurring in a recurrent cost, and fully managed by the service provider.

- (2) IaaS: Software deployed to a cloud infrastructure service, incurring in a separate recurrent cost for infrastructure, licensing costs for the software itself, and managed by your organization or a third-party contracted by your organization.

- (3) On-premise: Software deployed to infrastructure owned by your organization, and managed by your organization or a third-party contracted by your organization.

Note: Read the descriptions carefully, and make yourself familiar with the name of each of the three deployment methods. The questions that follow refer to these deployment methods.

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Matrix question - When deciding on a deployment method for the software solution you are intending to adopt: (1) SaaS, (2) IaaS, or (3) on-premise, how important is each of these factors?

Hint: Note that we are not discussing the software itself, but the way that the software is to be deployed.

Factor	(-2) Not important at all	(-1) Not very important	(0) Neutral	(1) Somewhat important	(2) Very important
Upfront and recurrent costs			Select one.		
Easy to upgrade			Select one.		
Ease of implementation			Select one.		
Security and privacy			Select one.		
Availability and reliability			Select one.		
Performance and scalability			Select one.		

Open ended question - Which are the most important factor(s) for your organization and why are they the most important?

Hint: This question is not mandatory. You may elaborate on your previous answer and include any information that you may feel relevant.

This is a free text question.

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Matrix question - Which deployment approach(es) is better at each of these factors, (1) SaaS, (2) IaaS, or (3) on-premise?

Hint: Select all that apply.

Factor	SaaS	IaaS	On-premise
Upfront and recurrent costs	[ ] Better [ ] Worse	[ ] Better [ ] Worse	[ ] Better [ ] Worse
Easy to upgrade	[ ] Better [ ] Worse	[ ] Better [ ] Worse	[ ] Better [ ] Worse
Ease of implementation	[ ] Better [ ] Worse	[ ] Better [ ] Worse	[ ] Better [ ] Worse
Security and privacy	[ ] Better [ ] Worse	[ ] Better [ ] Worse	[ ] Better [ ] Worse
Availability and reliability	[ ] Better [ ] Worse	[ ] Better [ ] Worse	[ ] Better [ ] Worse
Performance and scalability	[ ] Better [ ] Worse	[ ] Better [ ] Worse	[ ] Better [ ] Worse

Respondents select 1 or 2 factors as "Better", and 1 or 2 factors as "Worse".

Examples:

Upfront and recurrent costs	[x] Better [ ] Worse	[x] Better [ ] Worse	[ ] Better [x] Worse

Performance and scalability	[x] Better [ ] Worse	[ ] Better [x] Worse	[ ] Better [x] Worse

Open ended question - What is your preferred deployment method(s) and, in your view, in what ways does it stand out?

Hint: This question is not mandatory. You may elaborate on your previous answer and include any information that you may feel relevant.

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GDPR - Introduction

On 25 May 2018 the new EU General Data Protection Regulation (GDPR) comes into force. This requires organizations storing personal data to adhere to certain rules and practices.

GDPR compliance - With regard to GDPR compliance, in what situation is your organization?

A	We are not GDPR-compliant
B	We are GDPR-compliant

GDPR open ended - Have you been in contact with a vendor or consultant specialized in GDPR? What assurances or guarantees do you have to see your organization as GDPR-compliant?

Hint: This question is not mandatory. You may elaborate on your previous answer and include any information that you may feel relevant.
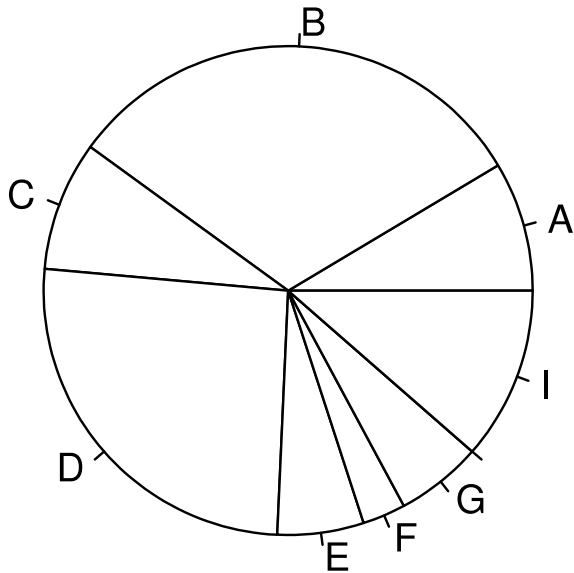
Appendix II: Results

Demographic

Organization and engineering effort size options map to the following table.

Option	Description
A	Self-employed
B	1-10 employees
C	11-50 employees
D	51-200 employees
E	201-500 employees
F	501-1000 employees
G	1001-5000 employees
H	5001-10,000 employees
I	10,001+ employees

Organization Size

Option	Description	#	%
A	Self-employed	3	8.57
B	1-10 employees	11	31.43
C	11-50 employees	3	8.57
D	51-200 employees	9	25.71
E	201-500 employees	2	5.71
F	501-1000 employees	1	2.86
G	1001-5000 employees	2	5.71
H	5001-10,000 employees	0	0
I	10,001+ employees	4	11.43

Engineering Effort Size
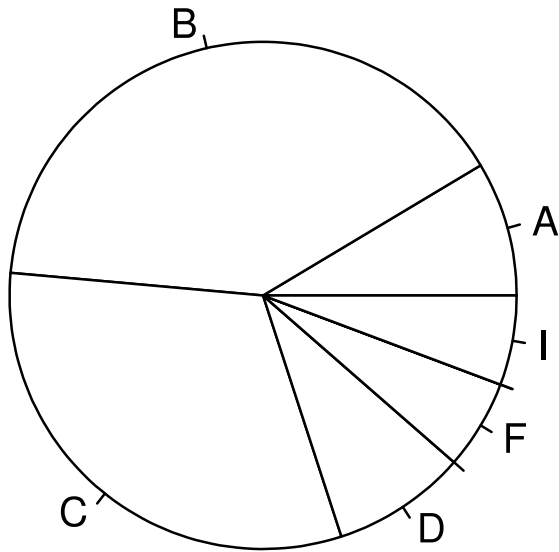
Option	Description	#	%
A	Self-employed	3	8.57
B	1-10 employees	14	40.00
C	11-50 employees	11	31.43
D	51-200 employees	3	8.57
E	201-500 employees	0	0
F	501-1000 employees	2	5.71
G	1001-5000 employees	0	0
H	5001-10,000 employees	0	0
I	10,001+ employees	2	5.71

Role
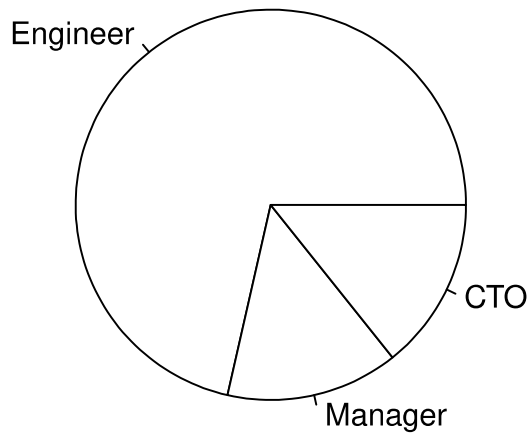
	#	%
Software Engineer, Developer	25	71.42
Manager, Director	5	14.29
CTO	5	14.29

Source
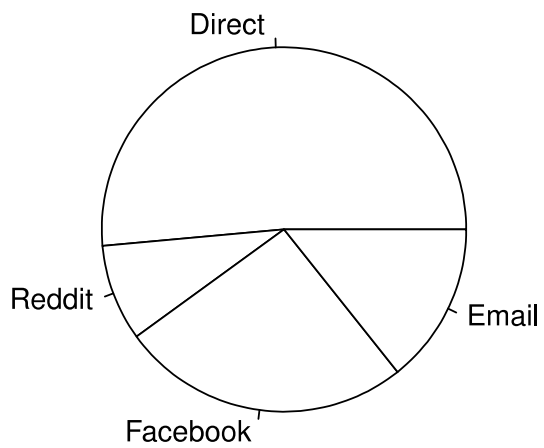
|	#	%
Direct	18	51.43
Reddit	3	8.57
Facebook	9	25.71
Email	5	14.29

Question 1

Frequency distribution

Columns are mapped to the factor importance Likert scale. Values are # of respondents. The most selected option for each factor is highlighted.

Factor	-2	-1	0	1	2
Upfront and recurrent costs	2	2	3	**15**	13
Availability and reliability	0	0	1	13	**21**
Ease of implementation	0	2	10	**16**	7
Performance and scalability	0	1	7	**15**	12
Security and privacy	0	0	7	10	**18**
Easy to upgrade	0	6	5	**21**	3

Boxplots
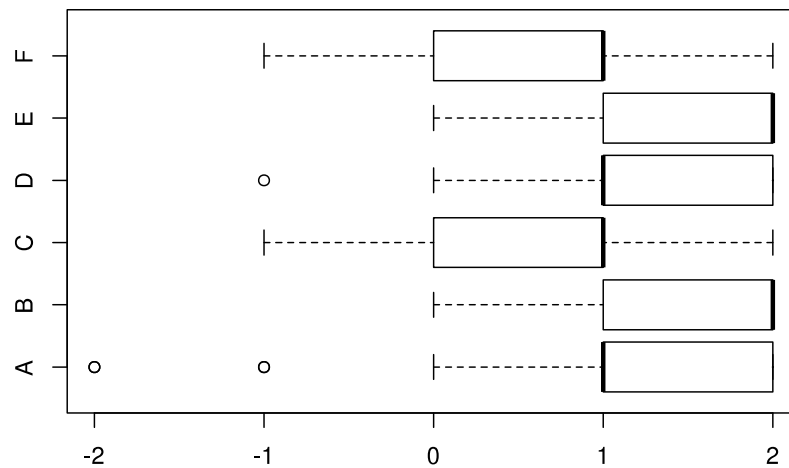
Factors on the boxplot chart are mapped to the following values.

A	Upfront and recurrent costs
B	Availability and reliability
C	Ease of implementation
D	Performance and scalability
E	Security and privacy
F	Easy to upgrade

Complementary open-ended question text answers

The report quotes respondents to give examples in the *discussion* section. This is the raw list of text respondents entered regarding Q1 (how important is each factor). In the report, respondents' input may have been rephrased for clarity.

"The fact that is can be maintained internally and no subscription costs" a CTO

"Availability is a big deal because there is strict reporting to the parent company, this has to follow a timeline. Reporting is done in a short timeframe towards the end of the month, the site has to be up." a System Developer

"It's super confidential, costs are not as important for the software itself as the security and privacy of the software." a Software Engineer

"Set up and ease of maintenance" a Principal Engineer

"Any time a software solution is being added / implemented, it's a delicate balance between cost of implementation and expected result and impact to overall bottom-line. The work required to implement any type of software solution should always pay dividends later on, so it's important to have a clear expectation of that the end-impact should be (i.e. how much time will it save operations / developers down the line) and this should be considered as part of the overall consideration and evaluation of the solution down the line." a Product Manager

"Our company is agile and ability to start using the software in weeks is much more important than costs." a Back-end Developer

Question 2

Frequency distribution

Factor	SaaS	IaaS	On-premise	#1
Upfront and recurrent costs	18 (51.43%)	**19 (54.29%)**	17 (48.57%)	**IaaS**
Easy to upgrade	**28 (80.00%)**	8 (22.86%)	14 (40.00%)	**SaaS**
Ease of implementation	**28 (80.00%)**	2 (5.71%)	12 (34.29%)	**SaaS**
Security and privacy	8 (22.86%)	10 (28.57%)	**29 (82.86%)**	**On-premise**
Availability and reliability	**25 (71.43%)**	15 (42.86%)	9 (25.71%)	**SaaS**
Performance and scalability	**24 (68.57%)**	5 (14.29%)	12 (34.29%)	**SaaS**

Complementary open-ended question text answers

The report quotes respondents to give examples in the *discussion* section. This is the raw list of text respondents entered regarding Q2 (which deployment method excels at each factor). In the report, respondents' input may have been rephrased for clarity.

"The software we purchase is installed internally and not connected to the web. we separate out public facing services" a CTO

"Depends on what the business logic is behind the decision. For certain internal processes like Sales software and internal communications it is easier to use SaaS products. For other things sometimes on prem makes sense due to TCO, other times leveraging some kind of IaaS or PaaS solution would give us enough flexibility and TCO is a wash given the trade offs." a Director of Sales

"Security and privacy depends on the company. If the company can handle security and privacy then it's better to have it on-premise, if the company is not good at security and privacy, a third-party that focuses on that would be more suitable." a System Developer

"Iaas seems good because it allows all the customization you could want but without hardware headaches" a Principal Engineer

"IaaS deployment is preferred for me, as it's the best of both worlds. You get an out-of-the-box component or solution from a SaaS perspective, but you have inherent control of the functionalities and broader project scope. Ideally, it would be best to build everything in-house and on-premise, but this is often time consuming for developers and internal resources, so it's often best to outsource as much of this development stage as possible while maintaining a high level of quality and functionality." a Product Manager

"SaaS is the best one as my company doesn't need to deal with infrastructure nor keeping up the servers." a Back-end Developer

Question 3

Results

GDPR compliant	#	%
Yes	14	40 %
No	21	60 %

Statistical Test

FACTOR	T1			T2(>) (gdpr, non-gdpr)			T2(<) (gdpr, non-gdpr)		
	alpha	p-value	significant	alpha	p-value	significant	alpha	p-value	significant
Upfront and recurrent costs	0.05	**0.04509**	YES	0.025	**0.02254**	YES	0.025	0.9793	NO
Availability and reliability	0.05	0.6231	NO	N/A					
Ease of implementation	0.05	0.2798	NO	N/A					
Performance and scalability	0.05	0.2719	NO	N/A					
Security and privacy	0.05	**0.02115**	YES	0.025	**0.01057**	YES	0.025	0.9904	NO
Easy to upgrade	0.05	**0.002376**	YES	0.025	**0.001188**	YES	0.025	0.999	NO

From these results we can say there is statistically significant evidence to say that GDPR has an influence on the decision in therms of the following factors:

- Upfront and recurrent costs
- Security and privacy
- Easy to upgrade

Complementary open-ended question text answers

The report quotes respondents to give examples in the *discussion* section. This is the raw list of text respondents entered regarding Q3. In the report, respondents' input may have been rephrased for clarity.

The original question on the questionnaire was "Elaborate. Have you been in contact with a vendor or consultant specialized on GDPR? What guarantees does your organization have to view itself as GDPR-compliant?"

"No. We are a german based company. We are very conscious of GDPR an its implications." a Director of Sales

"We are only in the US at this time" a Principal Engineer

"We are currently working towards GDPR compliance, rolling out a SaaS solution to Cookie Preferences and Data Subject Access Requests. We'll also be making updates to our consent opt-ins, terms / privacy notices, and add some general resources for EU Users to help navigate their rights under GDPR. We'll serve a slightly different experience for EU and non-EU users based on IP to ensure GDPR compliance." a Product Manager

"Cookies were pain in the ass" a Backend Developer

"We're working with multiple vendors and lawyers to update our Cookie Preferences, Consent Opt-Ins, and user data protocols ahead of the May 25th deadline." a Data Integrity Manager