# SOCIO-ENGINEERING METHODOLOGY FOR CLOUD COMPUTING ANALYSIS

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Abstract: Detecting potential cloud computing services is part of business direction and strategic planning of enterprise IT management companies. However, this relative new territory examination requires careful analysis that incorporates both external and internal organization perspectives. The socio-engineering methodology for cloud computing analysis (SEC) employed in this paper is aimed at discovering the potential cloud services that are of interest to the company as a whole. The investigation results were inserted into the company strategic technological evaluation process. The methodology was based on both qualitative and quantitative analysis techniques, incorporating interviews, surveys, questioners and an iterative review process. The results formed the company's cloud taxonomy, as well as highlighted 4 main players and 18 potential domains of services.

## 1 INTRODUCTION

Sociol- and engineering viewpoints on cloud computing taxonomy and utilization vary between the cloud players. In such settings, an IT management firm needs a consistent way for detecting potential new services offered to these players. Thus, the main challenge of such an investigation is the diversity of opinions and consequently, the detected services and their consumers. Accordingly, a methodological approach for cloud services categorization is in order. One approach may be to enumerate the ideal IT Services For Cloud players (ITS4C) that an IT firm should provide to cloud participants, assuming the cloud will be fully embraced (fully elastic, multiple domain of administration, composite dynamic applications). Based on Grounded Theory analysis (Strauss and Corbin 1990, 1994), and its adapted usage in this paper, the detection of such services enables the classification and categorization of the cloud IT management dimensions and changes. Moreover, we developed an analysis methodology termed Socio-Engineering Cloud analysis (SEC), which is a permuation and extesion of the methodology proposed by Aviv et al. (2008) (see also Levi et al., 2009). SEC aims at providing a comprehensive framework for analyzing potential cloud services.

This paper describes the SEC methdology, including (1) identifying analysis dimensions where domain problems and opportunities might occur (cloud types); (2) identifying key prototypical players and core business processes in the selected area (roles); and (3) identifying potential management, security and governance categories and sub-categories that are mapped to the prototypical players (later to support business cases and opportunities).

The methodology highlights several dimensions and characteristics of the cloud, according to the detection of the potential services and how they should be categorized. The investigation included organizational analysis, inventory of existing company activities, existing R&D development processes, company related culture and hype, survey construction, and previous corporate work. Morover, the inquiry included descriptive capturing,


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procedural/sequential use-case analysis and mapping of existing solutions.

Since our objective was to describe a complex observation regarding cloud perception and interpretation in its natural settings and its full complexity, we have used the Grounded Theory qualitative research paradigm (Strauss and Corbin 1990, 1994), which focuses on case studies for obtaining specific insights rather than on large populations, simplified experiments, and statistical methods for discovering universal laws. Qualitative research methods have long been recognized as important and contributing to software engineering research (see, for example, Seaman 1999). During this research, we documented, recorded and analyzed relevant cases and processes. The data analysis included coding the data obtained, characterizing and classifying it to emerging categories.

The sections below define the Socio-Engineering methodology for Cloud (SEC) design and research phases are detailed in section 2. Section 3 presents the results of this work, followed by a short conclusion section.

# 2 SEC DESIGN

The Socio-Ecumenical methodology for cloud analysis (SEC) is designed for gathering and aggregating the information needed to detect potential cloud services. The authors aggregated ideas and data sources from myriad sources, including interviews, conversation, and brainstorming with thought-leaders in the company's technical community. The discussions and brainstorming sessions in particular targeted engineers to stimulate the generation of new ideas relevant to the domains in question. The technique was conceived as bring-the-future-to-the-present to foster creative, no-barriers thinking by the participants. Several small-size teams iteratively reviewed the ideas raised throughout these discussions, thus, leading to incremental improvements.

During the research, we modified and extrapolated upon the combined Socio-Engineering Knowledge Audit Methodology (SEKAM) (Aviv et al. 2008 and Levi et al., 2009). The research method applied in SEC was based on the method engineering approach that aims to conceptualize, develop, adapt and assemble new methods from existing ones (Champlain, J. J. 1999, P.M.I. 2004, Sivan 1999, Perez-Soltero et al. 2006). In this research, we utilized the method engineering approach using these five phases: research goals setting, detection of the analysis dimensions characteristics and origins of information, data collection and interviews, information organization and aggregation.

As noted in the previous section, we used in this research data collection and analysis tools from the Grounded Theory approach (Strauss and Corbin, 1990, 1994). for the purpose of studying social and technical phenomena and observations without formulating the hypotheses in advance (Strauss and Corbin, 1990; Orlikowski, 1993, Denzin and Lincoln, 1994). The research data was inductively coded, with open and axial coding mechanisms, until reaching data analysis saturation (Strauss and Corbin, 1990). Open coding refers to the analytical process of identifying concepts, ideas, and meanings from the collected research data, aiming at discovery, naming, and categorizing phenomena or domains according to their properties, dimensions, and incidences. Axial coding refers to the establishing of core categories and sub-categories from the categories revealed in the open coding stage. The categories that emerged from this analysis and the relations between them will be presented in the results section below.

## 2.1 The SEC phases

The overall SEC phasesare as follows:

**Phase 1: Research Goals Setting**
This phase includes identifying areas with cloud-oriented problems and opportunities while discovering key stakeholders involved in the selected area. The core business processes in the selected area are prioritized and one process is selected to be audited first.

In our study, this phase included literature review (Reeves 2009, Manes 2010, Howard 2009, Smith et al 2009, Dreyfuss et al 2009, Grossman 2009, Gillett 2009, Garbani and Mendel 2010, Gillett et al 2008, Heffner et al. 2010, Pring et al. 2009, Worthington 2009) for establishing key activities that should be carried out during the conceptual analysis. It also included goals setting with the company's executives, and clear definition of the requirements. The result was a cloud taxonomy and an initial list of potential interview questions, as well as expectation matching.

**Phase 2: Detecting the Analysis Dimensions Characteristics and Origins of Information**
This was done by applying Method Characteristics Framework (MCF) (Hackathorn, 1998). MCF is

based on domains comparison in two dimensions: breadth and depth. The breadth dimension focuses on conducting the analysis according to the organizational structure, inventorying existing activities and R&D development processes. It considers the cloud computing company culture and hype, when constructing the survey. The depth dimension analysis is focused on providing a description to the potential services, and preparing them for the survey.

The breadth dimension supports identification of the main research field characteristics. Here we identified five main characteristics that influence the quality of knowledge gathered in the context of Cloud Computing:

(1) Organizational Analysis - including identifying the company's business units that may affect the cloud computing proposed services based on their known problems and needs, by interviewing chief architects. In our case a total of seven architects were interviewed.

(2) Inventory of existing activities within the company that have a cloud terminology associated with them, including potential patents. This phase included working with the patent office and business unit.

(3) Existing R&D development processes that consider cloud issues. These included in our case the Top Level Design Specifications of proposed projects, the Product Marketing Documents development, and strategic work on virtualization. The technological community as a whole was involved in gathering these data points. This phase included 24 interviews.

(4) Cloud Computing interest groups were engaged. Specifically, we investigated the cultural and hype activities in the company occurring within the technical community, including technology-scan documents, cloud interest groups, internal IT department and overall thought leadership around the cloud.

(5) Survey construction that contains the above dimensions mapped onto specific services coupled with skeleton examples. The survey questions were organized to more than 50 proposed IT services for the cloud (ITS4C such as federated security service, service optimizer, service analytics, service orchestration, etc.) to cloud players (provider, consumer, broker, developer), cloud types (internal, private, hybrid, public), as well as deployment methods (on and off-premise). The survey enabled participants to skip services not in their interest, add free comments, and indicate their level of expertise in a specific ITS4C. In addition, we codified the perceived market maturity for accepting a certain solution, and the difficulty in implementing it. More than 120 participants completed the survey across the company. The results of this survey are beyond the scope of this paper and will not be presented here.

(6) Previous corporate work was inserted as a disruptive analysis dimension. We scanned previous recommendations, or topics suggested, and considered how these different vectors might affect the overall depth of each proposed service, and how it might change the results' aggregation. We considered the company's software-as-a-service strategy, Alternative Delivery Methods strategy, and emerging and global trends.

The depth dimension supports analysis of each of the domains. We employed the following three levels (based on Levy et al. 2009):

(1) Descriptive – the potential conceptual service offering and proposed solution is defined by a theoretical description. This was used when the services proposed did not have existing implementations to the best of our knowledge.

(2) Procedural and Sequential – a sequence and example approach, where the solution is defined by a 'step by step' analysis, usually comprising a more granular approach to the "Descriptive" dimension, based on either written or defined invention disclosers, or other forms of commented analysis such as from the standard organizations. Examples may be cloud bursting scenarios, provision servers to satisfy seasonal or temporary needs, and cloud to cloud backup.

(3) Practical and existing – the method provides elicitation and analysis of existing solutions done by competitors, ones that exist within the company or under development. Example are cloud data backup, existing infrastructure renting, and sales and client relationships management services.

**Phase 3: Initial Analysis**

The domain analysis players, stakeholders, and categories are organized into four domains of players (consumers, providers, brokers, developers) coupled with the four types of clouds (Internal, Private, Hybrid, Public). Accordingly, we observed 11 IT concerns. as displayed in Figure 1 (assets, location, cost model, software development, network, hardware, capacity, identity, data, process, liability and risk), and their relevant characteristics in traditional datacenters, outsourcing and cloud environments. SEK considers all dimensions when analyzing the different ITS4C services and consequently, their technical possibilities

**Phase 4: Data Collection and Interviews**

Non-structured interviews and structured survey defines the aggregation of proposed technology and solution into buckets. Refinement and changed to buckets is done and reviewed by a steering committee. The interviews were performed in an

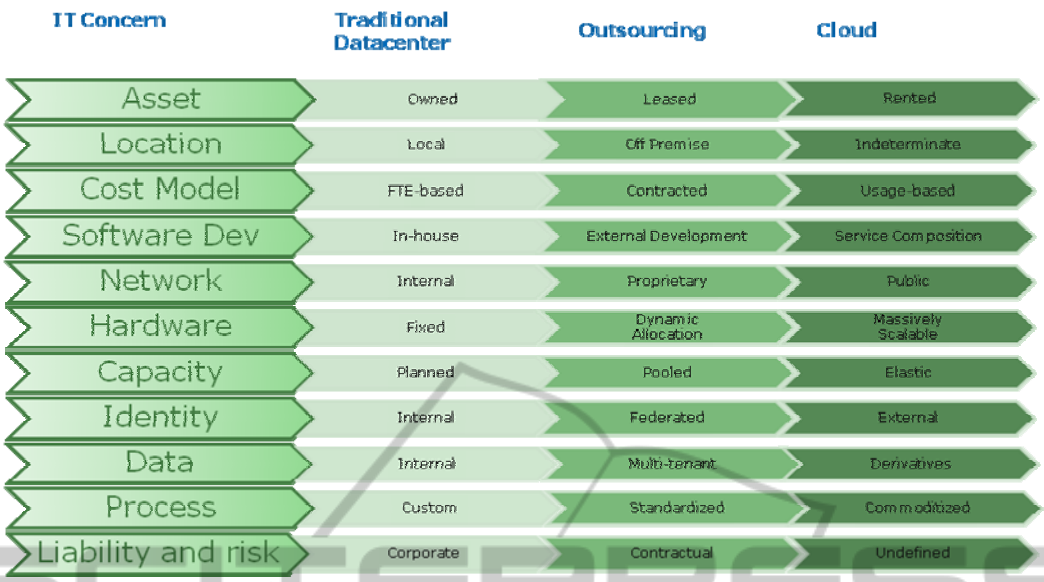


Figure 1: IT Concerns that are modified in different aspects of IT from a traditional datacenter to outsourcing and on to cloud computing.



iterative manner..

**The first step** was a cycle of interviews involved non-structured interviews with the highest executive and technical leadership of the company, coordinating and accurately defining the research goals, basic terminology, example of a service, and followed by an unstructured brainstorming conversation, enabling the participants to comment freely on their thoughts. The conversations were recorded, transcripts and analyzed. The questions in our interviews were, for example: What do you or your customers think about the cloud? What problems reside within the cloud needed to be solved? What prevents our current customers to go to the cloud, and how can we solve that? Overall, 24 interviews were conducted.

**The second step** was launching a survey. The survey questions were aimed to collect and count codified information. The main vertical access of the questions was the breadth of list of aspired services that were detected during the interviews, and the sources of information. The content of each question contained the depth characteristics of phases 2 and 3. In addition, an open form was provided for adding more examples and content (scenarios) to the services' depth.

**The third step** is forming buckets of aggregated categorization exemplified on Figure 2, aiming at finding a common characteristic that defines a solution approach, rather than a list of specific categories. The buckets are mainly used to present associations between the collected data, structured as a pyramid illustrating possible alternatives for the company's cloud-based vision and its validity in the collected data. The top layer includes the name of the bucket and its vision, the one right below contains the categories of themes harvested by SEC on the cloud, the third contains the aspired IT services for cloud players (ITS4C), the forth maps these services into existing activities, and the lowest layer contains examples, employing the use case approach.

**The forth step** involved reviewing these structures with the leading chief technologist, and overall company strategy team, figuring out the source of presentation, missing parts, or additional visions that are not highlighted enough. Typical questions were: Are we aggregating the areas correctly? Are we identifying opportunities correctly? What are we missing? What do you think you need to solve and how?

**The fifth** and last step involves improving the buckets defined categories, adding more content to. examples and use cases, and overall organizing and iterating to improve the quality of the results

**Phase 5: SEC Information Organization and Aggregation**

Revisiting the entire gathered material, and iterating back to the appropriate phase if needed. Formal documentation is produced, and audience presentations and communication are commenced.

This phase involves breaking and re-assembling back the properties and services detected in previous phases into common formalism, adjusted to the receiving audience. Communication material is

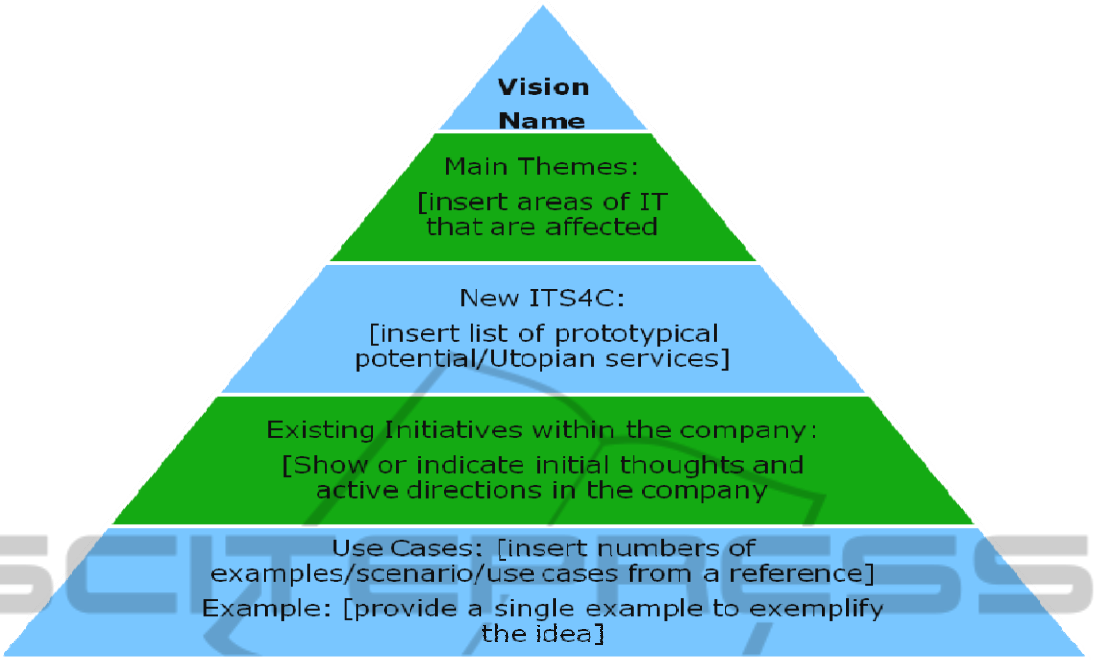




Figure 2: Buckets forming of potential IT Services for Cloud (ITS4C), actual work done on cloud, and examples that are based on case studies and use-cases.

produced, results are mapped to overall market trends and market analysis, showing potential horizon for solution readiness, documentations and white papers are produced, and overall stabilization of the results is finally achieved.

## 3 RESULTS - CLOUD COMPUTING SERVICES ANALYSIS

Analyzing IT Services for Cloud Players (ITS4C) requires indentifying prototypical problem areas for each player. SEC proposes the breath dimensions for sources of categories, and depth dimension for level and types of details on each. Consequently, the ITS4C are categorized according to a prototypical role of a cloud player, whereas any organization is comprised of a combination of these prototypical roles. The prototypical cloud participants are consumers, providers (producers) and developers of cloud services, as well as brokers. A company may consume some cloud services from a public cloud, and provide other services for its internal cloud, or even aggregate services and offer the aggregated service on the public cloud. This variety of stakeholders and the supply-chain approach, highlight that potential IT services or capabilities that an IT management company can provide to a cloud player (as enablers), or foster cloud computing usage, is a continuum of services (Ferguson and Hadar 2010). While the company's prototypical cloud consumers are mainly enterprise customers, providers and brokers present new opportunities to exploit for the SMB (Small Medium Business) market.

Figure 3 details how use cases and existing initiatives as well as thought-leadership form the new ITS4C and areas of interest by finding roles, categories and sub categories of the potential domains as emerged via SEC.

**ITS4C Consumers** cater for the IT shop that manages cloud services for the end-users and the recipients of cloud service. In the context of IT management, service consumer's management aspects manage IT as a business. As such, it includes several domains of interest that are extrapolated using similar terminology from ITIL v3.0:

*Service Strategy* contains the project and portfolio (PPM) component that enables the organization of the IT strategies and ongoing initiatives across all cloud domains in an agile manner, according to optimization suggestions. The strategy contains cloud financial management that is connected to the brokering commerce solutions, as well as to the monitoring and metering of the consumed services via the Service Operation of the providers.

*Service Design* provides service level management that uses monitors from the Operation support. It enforces federated security, and proactively solves service quality problems by planning capabilities through the analysis of IT behavior, detecting utilization patterns and change history.

The *Compliance and Governance services* provide transparency into the consumed services via reporting and auditing, as well as manage the distributed data and records (managed information) within the distributed services.

The *Business Process Utility (BPU)* services capture the overall IT management processes, used by the consumers in commoditized process, balancing processes, time and labor management using virtual labor management.

*Service Transition and Control* is responsible for ensuring the quality of requested services. The inventory and catalog is responsible for tracking the quality of the used services. The service configuration management maintains information on the services deployed topology. The service lifecycle manages changes in services, including request for usage and termination of service.

**ITS4C Providers** cater for companies that operate cloud computing environments for either internal consumers (such as internal cloud), a collaborative restricted environment (such as private clouds), or provide these services for external users, such as the case of a public cloud offering. In the case of internal cloud, the Service-Provider IT-services, which are enablers to the cloud providers, aim at improving the enterprise's internal resources utilization, and manage the growth of IT. This includes the handling of new technologies such as Server Virtualization. The case of internal and private cloud services can include either enterprise organizations with a single or multiple IT administration, or traditional service providers. The IT service categories are:

*Service Operation* that deals with the definition and monitoring of the availability and performance of deployed IT assets. It provides an operations dashboard that displays the overall status and health of the system to the consumer. Business continuity management is responsible for ongoing provisioning, recovery, backup and redundancy of the IT assets within the datacenter and the infrastructure in large, as well as countermeasures and remedy. A service desk and incident management component provides the ability to restore IT services back to operation through a workflow and lifecycle of incidents that conclude with incident resolution. Service capacity management compares alternatives for IT resources by analyzing costs and quality, conducting load tests, and accordingly adjusting the definitions.

The Security management is achieved through the identity and access management services, which manage users and controls their access to the resources. Information security management defines the needed associations and limitations in order to reduce the threat of information inappropriate usage.

**ITS4C Brokers** provide solutions for both consumers and providers of IT services, by facilitating collaboration between them and enabling an commercial trade. Service brokering generates revenue by facilitating the trade and business relations amongst them, including multiple participants. These services include:

*Service Integration* that negotiates agreements with supply chain services, sets agreements for operations and services, and catalogues the results. They facilitate federated security amongst a collection of multiple administration domains, and broker the identities.

*The Discovery* of new service offerings are captured on a public cloud catalog that provides quality measurements, indicators and trends on candidate services, as well as conducts optimization analysis according to consumers' requests.

Finally, the *Financial Services* provide an e-commerce arena, facilitating trade, and conducting financial activities according to consumers and providers requests of billing or procuring services.

**ITS4C Developers** cater for IT shops that need to build and deploy a software offering on the cloud ecosystem. Thus, the IT services include the construction, testing and provisioning of new services. The main aspect with regard to IT services is the *release management* that is responsible for testing a changed item prior to releasing it into the system. Thus, this component builds and organizes the deployed packages, and rolls out the change request to the operation services.

# 4 CONCLUSIONS

This paper defined categories in which potential IT Services for Cloud players (ITS4C) can be highlighted, and thus provide opportunities for an IT company. The analysis provides observations into potential IT services, catering for prototypical cloud participants (consumer, provider, broker and developer of cloud services), as well as four domains that affect mostly the type of software delivery

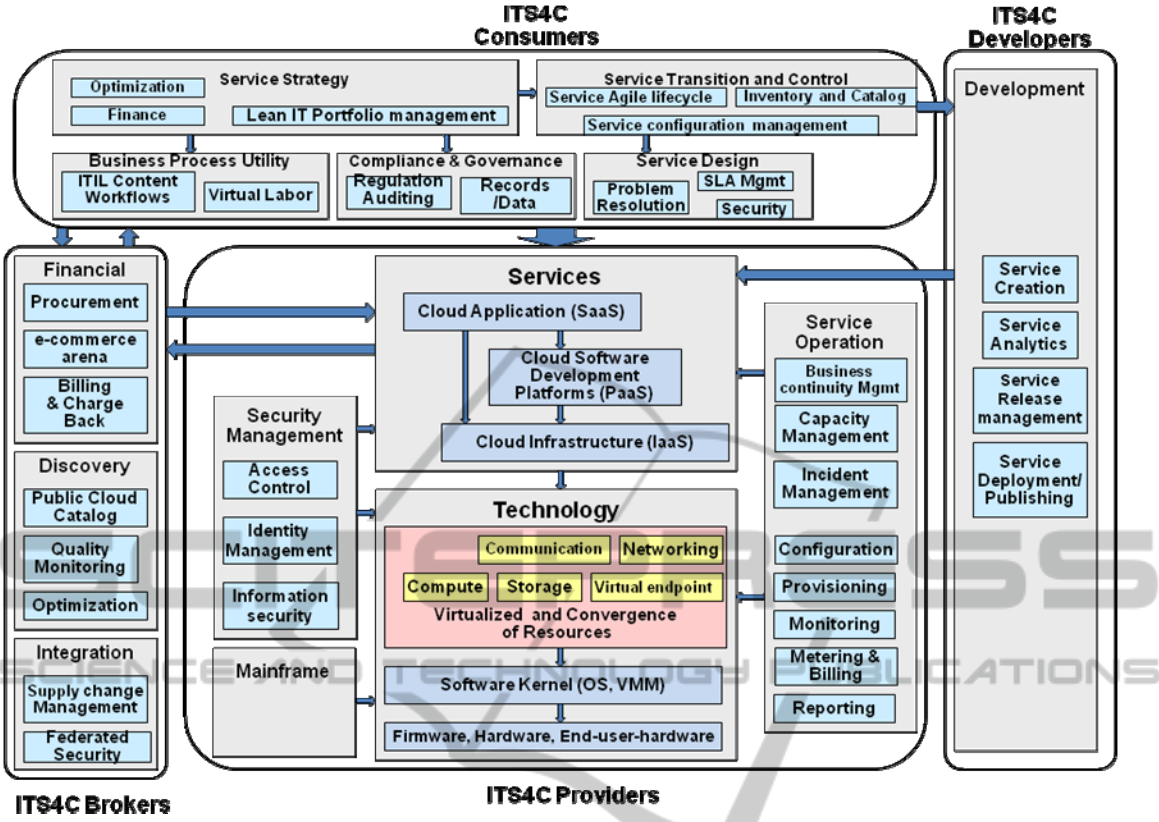


Figure 3: IT Services for Cloud Players (ITS4C) and their internal categories. The IT service categories are illustrated in light-blue boxes, and main categories in gray boxes, according to potential customers.

(internal, private, hybrid and public), as well as limitations on security and administration.

The setting and analysis of this paper, as well as the detailed definition of our research methodology, serves the corporate technological investigation. Since the detailed list of services detected is proprietary, these results are not included in this paper. However, this paper provides the setting and background for a methodological investigation and a comprehensive framework for analyzing and identifying cloud-based potential IT services.

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