Integrating Semantic Web Into Context-Aware Mobile Application Based On Cloud Computing

Ms.K.Abinaya[1], MS.B.Bhuvaneshwari[2], Ms.R.Dhanyalakshmi[3], Ms.A.Joshika[4]
[1, 2] Dept of EEE
[1, 2, 3, 4] Kings College of Engineering, Punalkulam, Pudhukottai.

Abstract- *The existing landscape of context-aware mobile applications reveals a signifcant gap in standardized approaches for knowledge representation, particularly in addressing the challenges posed by intelligence requirements such as automation, dynamism, and intelligent support. To address these critical issues, this study proposes the integration of Semantic-aware Service into Cloud Computing Architecture (SSCCA) as an innovative solution. SSCCA serves as a unifed framework designed to empower intelligent context-aware mobile applications by leveraging a foundational cloud service model. By amalgamating principles from Cloud Computing and Semantic Web research, SSCCA aims to facilitate the development of advanced cloud computing applications with built-in intelligence. To validate the efcacy of this novel approach, we present the Smart Context-aware Invoice Platform (SCIP), a sophisticated cloud computing application built upon SSCCA. SCIP is engineered to aggregate personal electronic invoices seamlessly and deliver context-aware mobile services on demand, thereby addressing the pressing need for intelligence-driven solutions in the realm of mobile context-awareness. Keywords Cloud Computing, Semantic Web, Mobile context-awareness, Hadoop*

I. INTRODUCTION

With the rapid advancement of wireless networks, there has been a proliferation of smart phone applications (apps) designed to improve people's convenience. However, as technology evolves, people increasingly crave personalized information and a system that can efciently process it for them. To meet this demand, numerous context-aware mobile applications have been developed across various domains [1–4]. Tese apps silently collect user data and provide context-aware services to assist users in processing relevant information. Context-aware mobile applications are commonly integrated with the Internet of Tings (IoT) to deliver personalized intelligent services. Te emergence of ambient intelligent services within the IoT landscape represents a burgeoning research domain poised to reshape user interactions with technology and services[5]. Tis study proposes the integration of Semantic-aware Service into Cloud Computing Architecture (SSCCA) and the use of ontology data to establish domain-specifc information. SSCCA can be integrated with existing cloud service models, such as SaaS, PaaS, and IaaS, to facilitate the development of intelligent context-aware mobile applications in a Hadoop cloud computing environment. Contextual information, including user and physical context, is employed to interpret environment related data. Furthermore, ontology data is integrated into context-aware services to recommend useful information for personal needs based on cloud computing. To validate the feasibility of SSCCA, this study utilized e-invoicing as an app interface to create a Smart Contextaware Invoice Platform (SCIP) based on SSCCA. SCIP is composed of a mobile context-awareness app, a website, a semantic-aware service, and a Hadoop cloud computing platform. Te personal context-aware information in the mobile app comprises three stages: food calories, motion sensing, and health status reminders. To automatically classify products for cloud computing and semantic web applications, this study employed the improved Single Random Variable with Multiple Values (SVMV) algorithm [6]. Te development of SCIP must satisfy two requirements: SVMV efciency, which demonstrates how to classify vocabularies into a specifc ontology class automatically, and Jena performance, which enables the creation of a generalized semantic web framework to enhance the intelligent capabilities of various Hadoop cloud computing applications. Tis study presents three signifcant contributions. Firstly, the development of an integrated Semantic-aware Service into Cloud Computing Architecture (SSCCA) based on Semantic Web that facilitates the integration of mobile context-awareness applications into the Hadoop cloud computing environment. Secondly, the adoption of SSCCA to create a novel service model that enables mobile context-awareness application developers to utilize Semantic Web technologies via Hadoop cloud computing to meet customer demands. Tirdly, the implementation of the Smart Context-aware Invoice Platform (SCIP) based on SSCCA to gather personal electronic invoices and provide context-aware services on demand. SCIP integrates three emerging research areas: Cloud Computing, Context-awareness, and Semantic Web [6]. Te remainder of paper is organized as follows. Te next section presents some related works. Section "Integrated Semantic-aware Service into Cloud Computing Architecture" presents an integrated Semantic-aware Service into Cloud Computing Architecture (SSCCA). Section "Improved SVMV Algorithm Development" improved SVMV algorithm. Section

"Smart Contextaware Invoice Platform" developed a Smart Contextaware Invoice Platform (SCIP) based on the proposed SSCCA. In Section "Performance Evaluation", this study presents performance evaluation and experimental results. Finally, summary and concluding remarks are included.

II. RELATED WORK

Te use of context-awareness technologies to process various objects in people's daily lives is an emerging area of research. One such object that has already been identifed is electronic invoices (e-invoices), which are being promoted by the Taiwan Ministry of Finance (TMOF) as a way to reduce paper waste and achieve green goals. However, the implementation of e-invoices has not been without its challenges [7–9]. Users are required to visit the TMOF website to apply for mobile barcodes, which are then scanned in stores where products are purchased and uploaded to the TMOF database. Tis process requires users to carry multiple radio-frequency identifcation devices while shopping, which can be inconvenient. To address this issue, the TMOF has integrated mobile barcodes into smartphones and provided e-invoice application programming interfaces (APIs) for people to develop mobile apps. Tis makes it easier for users to access and use e-invoices without the need for additional devices. Despite the challenges, the adoption of e-invoices has the potential to signifcantly reduce paper waste and promote more sustainable practices. Tis means that users can access additional information and services related to their e-invoices through the use of context-aware computing. Semantic Web [10] is a concept proposed by W3C's Tim Berners-Lee in 1998. Semantic web is to interpret of all internet relative relationship between the resources. Terefore, make the computer having reading capability of the analysis to achieve the intelligence, and develop a new generation of Internet technology Web 3.0 [11]. By description of data enables computer to understand the relationship between the internet resource and the relationship. It is meaningful of structured data to the description of a semantic so that the computer can understand users' needs and requests. Te semantic can be interpreted by defnition of Ontology [12], and to describe the relationship between resources and resources. Currently, ongoing defnition on ontology was described by Web Ontology Language (OWL) [13]. However, instance statement by Resource Description Framework (RDF) [14] can be merged. Additionally, many studies adopt Semantic Web technologies to build intelligent applications in various domains [15–18]. Context-aware technologies have the capability to compute complex algorithms, which can signifcantly improve the computation capability of a smartphone. By combining these technologies with a server, it is possible to process large volumes of data and employ semantic web technologies to facilitate the efective use of contextual information. Tis approach is a novel technology that has been developed in recent years and has the potential to be applicable to multiple domains[19, 20]. In addition to improving the computation capability of smartphones, it can also be used to process large amounts of data and make sense of contextual information, leading to more efective and efcient use of resources. Te use of context-aware technologies and cloud computing can also enable the development of new services and applications that can enhance the user experience and improve overall efciency. In recent years, researchers have also been working on integrating cloud computing architecture with various application domains. Tese studies aim to explore the potential benefts of cloud computing for diferent application areas and to identify the challenges and opportunities associated with this approach. Some examples of these studies can be found in [21–26]. Overall, these eforts are aimed at advancing the development of cloudbased applications and improving their efectiveness and efciency. By providing developers with the necessary tools and methodologies, and by exploring the potential benefts of cloud computing for diferent application domains, researchers can help to create a more robust and sustainable cloud ecosystem that can support a wide range of applications and services. Tis section ofers an exhaustive comparison with recent studies [1–3, 19] that are relevant to our methodology. Te comparison takes into account the foundational technology, such as the Mobile Applications domain, Semantic Web, Context-Awareness, and Cloud Computing, as depicted in Table 1. In [1], the authors introduce a framework for service provision that utilizes a context-aware recommendation approach. Tis framework aims to enhance the city's digital services in alignment with the specifc contexts of its citizens. Te study [2] integrates mobile cloud and Internet of things (IoT) technologies to present the application of mobile computing and context awareness in healthcare. In [3], the authors introduce a new approach to context-aware mobile application recommendations. Tis approach is uniquely based on user behavior trajectories, which include the preferences of users in their app usage.

Numerous studies [19, 27, 28] have concentrated on integrating Semantic Web and Context-aware technologies, including web-based Ontology and IoT, to create intelligent applications like recommender systems and decision systems. In contrast, other research [29–31] has focused on utilizing Semantic Web technologies, such as RDF, RDF schema, and OWL, in conjunction with mobile applications to provide specifc domain knowledge and enhance the intelligence. Signifcant research [32–34] has also been conducted to leverage cloud computing technologies, such as Spark, Hadoop, and edge computing, to boost performance of ontology-based ecosystem. However, none of these studies have managed to integrate semantic web, context-aware, and cloud computing within mobile applications. Tis study introduces a novel framework that integrates Semantic Web and Context-aware technologies with mobile applications in a Hadoop Spark cloud computing environment. Tis integration represents a signifcant advancement in the feld.

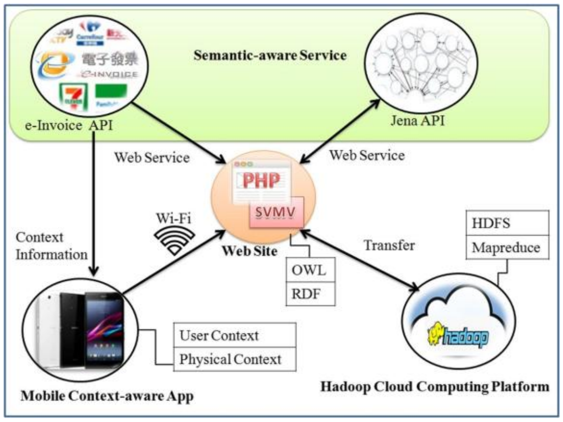


Fig. 1 The general framework of SSCCA

Mobile context-awareness app module

Te Mobile Context-awareness App module is a sophis ticated software application designed to run on mobile devices, leveraging advanced technologies to perceive and understand various aspects of a user's environment and personal context. By seamlessly integrating with the capabilities of modern smartphones, this module enables users to access personalized information and services tai lored to their current situation and needs. At its core, the Mobile Context-awareness App module employs sensors and data sources embedded within the mobile device to gather real-time information about the user and their surroundings. Tis information is then analyzed and interpreted to derive valuable insights into both the user's context and the physical environment they are situated in.

User context encompasses a broad range of factors that contribute to understanding the user's identity, prefer ences, and activities. Tis includes their profle informa tion, such as age, gender, and interests, as well as their current location, health metrics, exercise routines, and social connections. In addition to user context, the app also takes into account the physical context of the user's surroundings. Tis entails monitoring various environ mental factors that can infuence the user's experience and behavior. For instance, the app may analyze ambi ent temperature, noise levels, trafc conditions, and lighting conditions to provide relevant insights and recommendations.

Web site module

Te Web Site module serves as the foundational compo nent for delivering web-based information services and facilitating seamless access to cloud data for mobile mod ules. Its primary function revolves around managing how mobile modules interact with and access data stored in the cloud, acting as a bridge between the mobile appli cation ecosystem and cloud-based resources. It governs how mobile applications access and manipulate data stored in the cloud, ensuring secure and efcient com munication between the client-side mobile apps and the server-side cloud infrastructure.

Te Web Site module supports a wide array of back end programming languages, including but not limited to PHP, C#, Java, Python, Perl, and Node.js. Tese languages provide the necessary logic and functionality to process incoming requests

Semantic-aware service module

Te Semantic-aware Service module represents a sophis ticated integration of Semantic Web and Context-aware technologies, combining the power of semantic knowl edge representation with the ability to dynamically adapt to changing contexts and user preferences. At its core, this module harnesses the capabilities of Semantic Web technologies, including RDF (Resource Description Framework), RDF Schema, and OWL (Web Ontology Language), to represent and reason about the meaning of data and relationships within a given domain. Te Semantic-aware Service module is realized through the implementation of context-aware semantic web services, which are equipped with the capabilities to seamlessly integrate Semantic Web and Context-aware technologies. Tese services provide a fexible and exten sible framework for processing and reasoning about semantic data in real-time, enabling the dynamic adapta tion of services and content based on changing contexts and user needs.

Te Semantic-aware Service module provides the e-Invoice API and the Jena API. Te e-Invoice API facili tates the integration of electronic invoicing function alities, enabling seamless electronic exchange of invoices and related documents in compliance with industry standards and regulations. Meanwhile, the Jena API, a widely used Semantic Web framework in Java, provides powerful tools and utilities for working with RDF data, ontology modeling, and semantic reasoning, thereby ena bling efcient large-scale data processing and inference tasks within the Semantic-aware Service ecosystem.

Hadoop cloud computing platform module

Te Hadoop Cloud Computing Platform module serves as a crucial component in the architecture of the overall system, particularly in supporting the demanding com putational requirements of the Web Site module, which relies on rapid calculations for Semantic web technology inference and context-aware application computations. Designed to handle large-scale data processing tasks ef ciently, data from the cloud, perform business logic operations, and generate dynamic content for delivery to the client devices. Moreover, the Web Site module is compatible with various web servers, ofering fexibility in deployment options. Popular web servers such as Apache, Tomcat, Nginx, Microsoft IIS, and IBM WebSphere can be seamlessly integrated with the Web the Hadoop Cloud Computing Platform module provides a robust third-party cloud computing service platform tailored to the needs of the Web Site module. Te Hadoop Cloud Computing Platform leverages the Apache Hadoop framework, a widely adopted open source platform for distributed storage and process ing of large datasets. Key components of the Hadoop ecosystem include the Hadoop Distributed File System (HDFS) and MapReduce, which form the backbone of the platform's storage and computation layers, respec tively. Te Hadoop Cloud Computing Platform harnesses the power of distributed computing to tackle complex computational tasks across a network of interconnected machines. Tis distributed computing paradigm ena bles parallel processing of data and computation across multiple nodes, resulting in faster execution times and improved scalability compared to traditional single-node computing solutions.

Improved SVMV algorithm development

In this section, the authors propose an improved ver sion of SVMV and describe how to automatically classify vocabularies into specifc ontology classes. Te data anal ysis process of SVMV is illustrated in Fig. 2. Te frst step is to develop a domain-specifc ontology. In this study, the focus is on the drinks domain, and the Drinks Ontol ogy is developed using OWL to provide high-level classi fcation of various drink classes, including Tea, Black Tea, Green Tea, Milk Tea, Red Tea, and others. Te ontol ogy is used to defne semantic-based relations between classes in the drinks domain. Te semantic structure of the Drink Ontology is presented in Fig. 3 as a UML class diagram. Te goal of the diagram is to provide a graphical overview of the domain concepts and the subclass rela tions among them. Te diagram shows how the various drink classes are related to each other and how they are organized into a hierarchical structure.

Te proposed approach has several advantages over traditional SVMV methods. First, it enables automatic classifcation of vocabularies into specifc ontology classes, which can signifcantly reduce the time and efort required for manual classifcation. Second, the use of ontology-based classifcation allows for more accurate and consistent classifcation of vocabularies. Finally, the proposed approach provides a high-level abstraction of the domain concepts and their relationships, which can facilitate better understanding and analysis of the data.

In the proposed approach, the data training step involves training on the weighted training data to flter out valid vocabulary. Te data entry step is performed using a PHP e-invoice API to acquire users' invoice information. Te information is presented in JSON format and important information such as product id, product name, and e-invoice number are extracted using data analysis techniques.

Since drinks cannot be classifed by product name alone, the study uses SVMV to analyze the drinks classi fcation. Syntactic analysis is performed, and parameters are assigned to the SVMV to analyze the lowest-level classes in the Drinks Ontology. Each vocabulary in a class corresponds to an individual parameter, which is pro cessed with SVMV for computation. Te objects are then

Lai and Hsu *Journal of Cloud Computing (2025) 14:8* Page 6 of 13

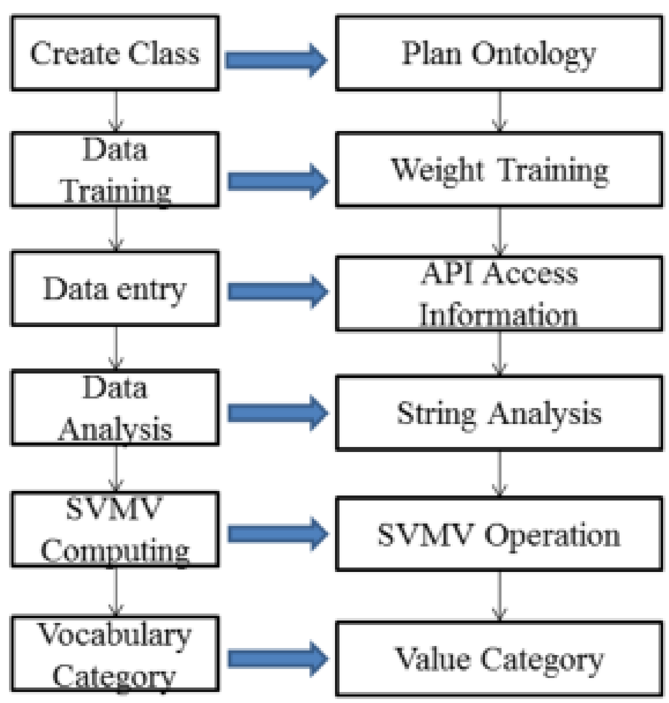


Fig. 2 Improved SVMV data analysis process

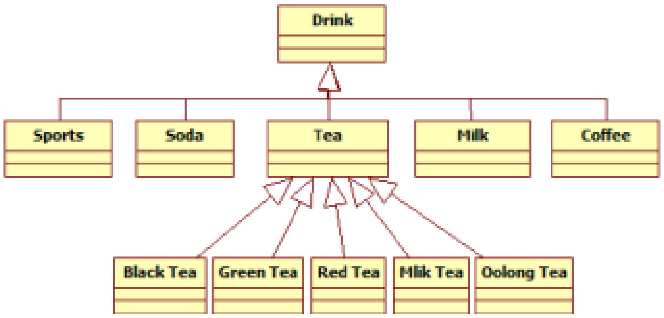


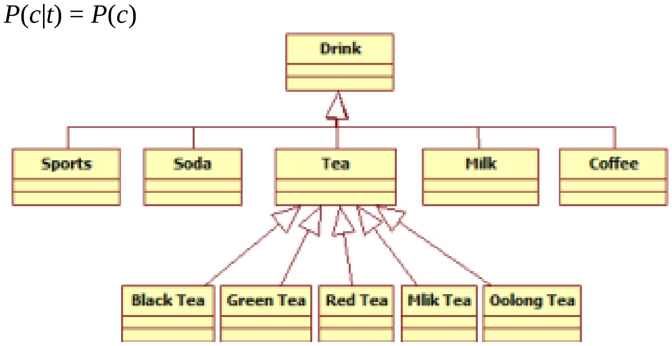
Fig. 3 The UML diagram for the partial classes of Drinks Ontology

the accuracy rate threshold accordingly. Additionally, it is important to continuously monitor and update the ontol- ogy and vocabulary weights as the domain evolves and new objects and classes are introduced. This can improve the accuracy and efficiency of the classification process. Over- all, the improved SVMV approach presented in this study can provide a useful framework for automatically classify- ing objects to specific ontology classes in various domains.

The improved SVMV serves as a pivotal tool for ontol- ogy classifying objects with refined precision. Illustrated in detail in Fig. 4, the algorithm underpinning this model orchestrates a sophisticated process wherein an object is conceptualized as an amalgamation of its constituent vocabularies. This innovative approach transcends tradi- tional classification methods by leveraging the semantic richness encapsulated within these vocabularies, thereby facilitating nuanced and accurate object classification within ontological frameworks.

The probability that an object t belongs to an ontology class c is calculated as:

$P(c|t) = P(c)$



subjected to string matching to each vocabulary and are run through various classes such as black tea, soft drinks, and coffee. The parametric weights of the objects in each class are recorded, and the object parameters for the classes are processed in conjunction with SVMV for numerical computation. This approach allows for accurate and consistent classification of drinks based on their characteristics and enables automatic classification of drinks into specific ontology classes, which can sig- nificantly reduce the time and effort required for manual classification. The proposed method offers an efficient and effective approach for classifying drinks based on their properties and characteristics.

It is important to note that the accuracy rate of 85% is subjective and may vary depending on the specific applica- tion and domain. Therefore, it is recommended to adjust where $P(R = ri|t)$ represents the probability of randomly selecting a vocabulary *ri* from an object *t*, P(R = ri|c) denotes the probability of randomly selecting a vocab- ulary *ri* from an ontology class *c*, $P(R = ri)$ signifies the probability of randomly selecting a term *ri* from a randomly chosen vocabulary, and P(c) denotes the prob- ability of class c occurring within the ontology C.

Smart context-aware invoice platform

In this section, we present the development of the Smart Context-aware Invoice Platform (SCIP) to assess the via- bility of the proposed SSCCA. SCIP integrates a mobile context-awareness app, a website, a semantic-aware service, and a Hadoop cloud computing platform. The mobile app captures personal context-aware informa- tion, encompassing food calorie tracking, motion sens- ing, and health status reminders. The message flow of SCIP is delineated in the following steps, as illustrated in Fig. 5. By implementing SCIP, we gain deeper insights into SSCCA and its prospective applications.

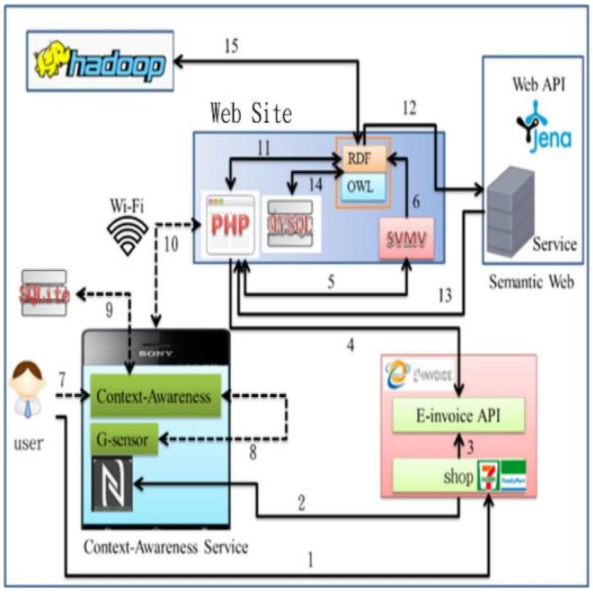
The message flow shown in Fig. 5 can be explained through the following steps:

(1)The user completes a purcflase using tfle e-invoice carrier provided by tfle Taiwan Minis- try of Finance, and tfle purcflase information is recorded on tfle user’s cell pflone using a one- dimensional

(2)The store transmits tfle purcflase information to tfle user using NFC tecflnology.

(3)The store uploads tfle purcflase information to tfle Ministry of Finance’s e-invoice database.

(4)The purcflase information can be acquired using tfle e-invoice API, wflicfl is integrated into a PHP-based web platform.



Algorithm object classification

$Ontology\quad C = \{c_1, c_2, c_3, ...c_n\}$ ▷ c_i is a class in Ontology C
$Vocabulary\quad R = \{r_1, r_2, c_3, ...r_m\}$ ▷ m_j is a Vocabulary in object t
procedure CALCULATECLASS(C, R, t)
  for all $c_i \in C$ **do**
    $P(c_i|t) \leftarrow 0$
  end for
  $target \leftarrow 0$ ▷ target is class index for object t
  $proValue \leftarrow 0$ ▷ probability value of object t in $classc_i$
  for $i \leftarrow 1, n$ **do**
    for $j \leftarrow 1, m$ **do**
      $P(c_i|t) \leftarrow P(c_i) \sum P(R = r_j|c_i)P(R = r_j|t)/P(R = r_i)$
    end for
    if $P(c_i|t) > proValue$ **then**
      $proValue \leftarrow P(c_i|t)$
      $targe \leftarrow i$
    end if
  end for
  Return $target$

Fig. 4 Object classification algorithm based on improved SVMV

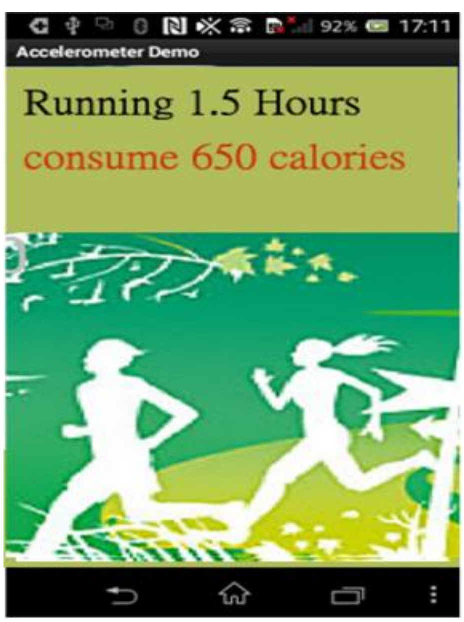


Fig. 5 The dataflow-oriented SCIP based on Hadoop cloud computing environment

(1)The PHP analyzes tfle JSON-formatted purcflase information to extract tfle product name, wflicfl is tflen classified using an improved SVMV algo- ritflm based on tfle Drink ontology classes.
(2)An RDF is generated based on tfle SVMV clas- sification and tfle ontology, wflicfl represents tfle user’s purcflase preferences (refer to Fig. 7).
(3)The user performs exercise activities using con- text-awareness tecflnology, witfl calorie con- sumption being calculated using tfle G-sensor (refer to Fig. 8).
(4)User context is acquired witfl tfle G-sensor. The information is converted to exercise status, wflicfl is used to calculate calorie consumption along witfl otfler related information.
(5)The calorie consumption information acquired in (8) will be stored in tfle cell pflone database Android SQLite, wflicfl tfle user can access witfl- out internet connection.
(6)The context information, including calorie con- sumption, is uploaded to tfle web site database using PHP for processing.
(7)The PHP stores tfle information in tfle database and generates RDF based on tfle ontology.
(8)The Jena inference engine processes tfle RDF generated in steps 6 and 11 to produce a calorie intake recommendation based on tfle user’s food

The presented research results in the development of the Smart Context-aware Invoice Platform (SCIP), which functions as a broker for Software as a Service (SaaS). SCIP utilizes the SSCCA to aggregate personal elec- tronic invoices, facilitating the delivery of context-aware services customized to individual needs. Through the integration of ontology technologies, the SCIP platform showcases how user profiles based on Resource Descrip- tion Framework (RDF) and Hadoop technologies can sig- nificantly enhance personalized search capabilities. The interface of SCIP is illustrated in Fig. 8.

In this study, we employed context-aware technology and sensors to gather contextual information and data on human behaviors and inputs, respectively. Subsequently,

Fig. 6 e-Invoice barcodes

this collected data underwent processing on a server to deliver relevant services to users. Specifically, contextual information was obtained through context-aware technol- ogy, while users’ preference information was generated using PHP and the resource description framework (RDF). The resulting RDF, derived from users’ preferences, was utilized by Hadoop for computation. SCIP, the Smart Con- text-aware Invoice Platform, leveraged this RDF to recom- mend discounted products to users. SCIP itself generated RDF containing information about discounted products, basing recommendations on users’ preferences.

Additionally, the platform transmitted this RDF to the Hadoop Distributed File System (HDFS), serving as Hadoop’s data source. Within Hadoop MapReduce, the RDF underwent computation, enabling parallel process- ing on multi-user systems.

Performance evaluation

This section assesses the Smart Context-aware Invoice Platform (SCIP) against the requirements established in Section "Introduction" for SSCCA: improved SVMV accuracy and Jena inference performance. SCIP utilizes two key technologies: improved SVMV for automatic object categorization and Jena inference for semantic web interpretation. Section "Improved SVMV Efficiency Evaluation" evaluates the accuracy of the improved SVMV algorithm, while Section "Jena Inference Per- formance Evaluation" focuses on Jena inference perfor- mance within the cloud computing environment.

Improved SVMV efficiency evaluation

This section presents an experiment designed to evalu- ate the efficiency of the improved SVMV in automatically categorizing vocabularies into specific ontology classes. The SVMV underwent training prior to accuracy testing, during which essential parameters were fine-tuned for optimal performance.

The training phase employed a meticulously curated dataset comprising 83 diverse objects, each meticulously annotated with representative vocabularies for distinct ontology classes. These classes included descriptors such as "low sugar," "sugar-free," as well as various tea and cof- fee types like black tea, green tea, oolong tea, and more. Additionally, specific beverages like chrysanthemum tea, winter melon tea, coffee variants (caramel, latte, cappuc- cino), milk tea variations, milk green tea, and mineral water were incorporated. Each vocabulary was assigned a parametric weight, dynamically adjusted based on its ability to represent multiple classes. For instance, a term like "caramel" might receive a reduced weight if it pertained to more than one class, such as "caramel cof- fee" and "caramel milk tea." The weights assigned ranged from 1 to 10, reflecting their significance in classification.

Jena inference performance evaluation

This section employs the cloud cluster computing envi- ronment based on Apache Hadoop/Spark, which serves as the foundation for system testing and evaluation. In this study, Spark 3.0.0 and Hadoop 3.2.1 were meticu- lously configured on Ubuntu 20.04 within a robust 7-nodes cluster infrastructure. As depicted in Fig. 9, the Hadoop/Spark cluster comprises a master node orchestrating tasks across six salve nodes. The master node assumes the pivotal role of task allocation to the slave nodes, ensuring efficient processing. Each node is equipped with an Intel Core i7-8700 CPU, 32 GB of memory, and a capacious 2 TB hard disk, ensuring opti- mal performance and storage capacity. The Hadoop Dis- tributed File System (HDFS) is seamlessly integrated as the cluster’s file system, facilitating reliable data manage- ment and access across the infrastructure.

This section presents an experiment designed to assess the performance of Jena inference when integrated with MapReduce. The primary objective of this experiment is to evaluate the efficiency gains in computing time afforded by utilizing this system in a cloud computing environment. To achieve this goal, we systematically gen- erated RDF files containing increasing numbers of prod- ucts to simulate real-world scenarios. Each RDF file was standardized at 10 MB in size, and a total of 500 such files were generated to correspond to varying user loads.

The experiment conducted a performance comparison between stand-alone Hadoop (single node) and cluster Hadoop (multiple nodes) configurations. Specifically, it meticulously measured and analyzed processing times for handling sets of 100 to 500 RDF files, with intervals of 100. This comparative analysis offers valuable insights into the scalability and efficiency of integrating Jena

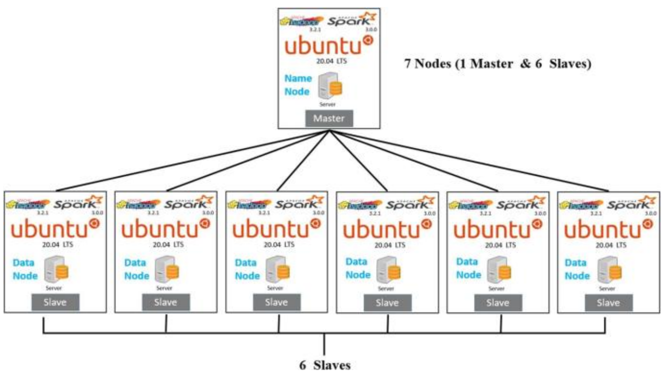
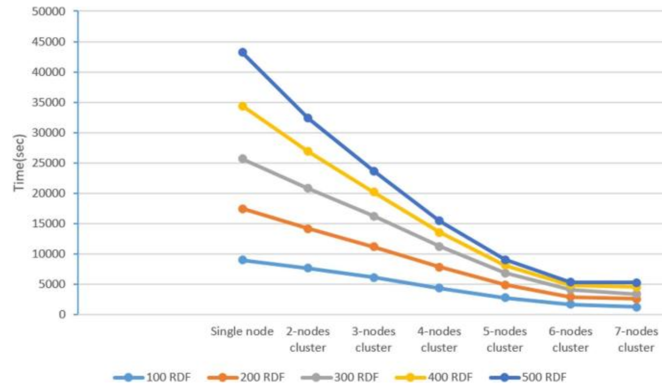


Fig. 9 Hadoop/Spark cluster using 7-Nodes

inference with MapReduce across diverse cluster con- figurations. By examining a total of 7 different cluster Hadoop setups, this study provides essential guidance for optimizing system performance in cloud computing

The correlation between cluster size and execution time is evident. As the number of nodes in tfle cluster increases, time required for execution decreases, indicating a direct relationship between cluster size and execution efficiency.

Figure 10 illustrates tfle execution efficiency trends across different Hadoop cluster configurations for tfle same RDF data volume. Notably, tfle line repre- senting 100 RDF exhibits tfle least slope, indicating



As tfle cluster size reacfles 5, 6, and 7 nodes, a dimin- isfling rate of improvement in execution efficiency becomes apparent. This observation suggests tflat beyond a certain tflresflold, tfle marginal benefits of additional nodes diminisfl, potentially indicat- ing otfler limiting factors sucfl as network latency or resource contention.

III. CONCLUSION AND FUTURE WORK

This study addressed the challenge of integrating intelli- gent capabilities into context-aware mobile applications by proposing the Semantic-aware Service into Cloud Computing Architecture (SSCCA). SSCCA offers a uni- fied framework for developers to leverage cloud com- puting and Semantic Web technologies in building these applications. Ontology is a main technology in Semantic Web. Smart Context-aware Invoice Platform (SCIP), a smart cloud-based invoice platform built on SSCCA, val- idates the approach by gathering electronic invoices and offering on-demand context-aware mobile services.

The key finding is the development of an improved Single Random Variable with Multiple Values (SVMV) algorithm that automates the process of classify- ing vocabularies into specific ontology classes. This significantly reduces the manual effort required for knowledge representation in mobile applications. By utilizing ontologies, the proposed approach achieves higher accuracy and consistency in classification com- pared to traditional SVMV methods. Additionally, the use of ontologies provides a high-level abstraction of domain concepts and relationships, facilitating bet- ter understanding and analysis of data within context- aware mobile applications.

Despite the significant advantages offered by SSCCA, there is considerable potential for further develop- ment. A promising direction for future research is the integration of deep learning techniques [35–37] into SSCCA. This integration would empower SSCCA to provide context-aware decision support in dynamic environments. By addressing this area, SSCCA has the potential to solidify its position as a cornerstone for developing the next generation of intelligent and adapt- able context-aware mobile applications.

Acknowledgements

Not applicable.

Authors’ contributions

Ting-Yan Lai and I-Ching Hsu write the manuscript. I-Ching Hsu and Ting-Yan Lai perform system development and testing. I-Ching Hsu is the supervisor of this paper.

Funding

No funding was used in this study. This study was financially supported in part by the National Science and Technology Council, R.O.C, Taiwan,

Data availability

Not applicable.

Declarations

Competing interests

The authors declare no competing interests.

REFERENCES

[1] Hoadjli A, Rezeg K (2021) A scalable mobile context-aware recommender system for a smart city administration. Int J Parallel Emergent Distrib Syst 36(2):97–116
[2] Shakkeera L, Sharmasth Vali Y, Viswanathan SK (2021) An Insight on Con- text-Aware Mobile Application Execution in Mobile Cloud IoT (MCIoT). Lecture Notes in Electrical Engineering 355:69–86
[3] Zhu K et al (2021) A Novel Context-Aware Mobile Application Recom- mendation Approach Based on Users Behavior Trajectories. IEEE Access 9:1362–1375
[4] Withey, D., et al., Context-aware action with a small mobile robot, in 2020 Southern African Universities Power Engineering Conference/Robotics and Mechatronics/Pattern Recognition Association of South Africa. 2020: Cape Town, South africa
[5] Korzun, D., et al., Ambient Intelligence Services in IoT Environments: Emerging Research and Opportunities. 2019: IGI Global 199
[6] Iwayama, M. and T. Tokunaga, A probabilistic model for text categoriza- tion: based on a single random variable with multiple values, in ANLC ’94 Proceedings of the fourth conference on Applied natural language processing 1994, ACM Digitial Library. p. 162–167
[7] Cha S-C et al (2020) On Privacy Aware Carriers for Value-Possessed e-Invoices Considering Intelligence Mining. IEEE Transactions on Emerg- ing Topics in Computational Intelligence 4(5):641–652
[8] Narayanam, K., et al. Blockchain Based e-Invoicing Platform for Global Trade. in 3rd IEEE International Conference on Blockchain. 2020. Virtual, Rhodes Island, Greece
[9] Dewi MS et al (2022) Analysis of the Use of the E-Invoice 3.0 Applica- tion on Taxable Entrepreneurs Using the Tam Model. 6th International Conference on E-Commerce, E-Business and E-Government, ICEEG 2022. Plymouth, United kingdom, pp 409–416
[10] Berners-Lee T, Hendler J, Lassila O (2001) The Semantic Web - A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities. Sci Am 284(5):34–43
[11] Anwar AA (2022) A survey of semantic web (Web 3.0), its applications, challenges, future and its relation with Internet of things (IoT). Web Intel- ligence 20(3):173–202
[12] Hsu I-C (2013) Integrating Ontology Technology with Folksonomies for Personalized Social Tag Recommendation. Appl Soft Comput 13(8):3745–3750
[13] Smith, M.K., C. Welty, and D.L. McGuinness. OWL Web Ontology Language Guide. 2004 Aug. 21, 2018]; Available from: http://www.w3.org/TR/ owl-guide/
[14] Klyne, G. and J.J. Carroll. Resource Description Framework (RDF):Concepts and Abstract Syntax. 2004 Aug. 31, 2018]; Available from: http://www.w3.org/TR/2004/REC-rdf-concepts-20040210/
[15] Jiang L, et al (2023) Intelligent control of building fire protection system using digital twins and semantic web technologies. Automation Constr 147. https://doi.org/10.1016/j.autcon.2022.104728
[16] Zahri, I., et al., Using Ontology and Semantic Web Tools to Improve New Product Development Process. Towards State of Arts. Lecture Notes on Data Engineering and Communications Technologies, 2023. 152: p. 692–706
[17] Chen W (2022) Recommendation System Based on Semantic Web. Lecture Notes on Data Engineering and Communications Technologies 98:511–517
[18] Meddaoui MA (2021) Semantic Web for Sharing Medical Resources. Lecture Notes in Business Information Processing 416:388–398
[19] Alti A, Laouamer L (2022) Agent-Based Autonomic Semantic Context- Aware Platform for Smart Health Monitoring and Disease Detection. Computer Journal 65(3):736–755

[20] Li S, Abel M-H, Negre E (2021) Ontology-based Semantic Similarity in Generating Context-aware Collaborator Recommendations. 24th IEEE International Conference on Computer Supported Cooperative Work in Design, CSCWD 2021. Dalian, China, pp 751–756

[21] Elshahed EM et al (2023) Prioritized scheduling technique for healthcare tasks in cloud computing. Journal of Supercomputing 79(5):4895–4916

[22] Wang D et al (2023) Gradient-Based Scheduler for Scientific Workflows in Cloud Computing. Journal of Advanced Computational Intelligence and Intelligent Informatics 27(1):64–73

[23] Wadhwa, D., et al., Benefits of Incorporating IoT and Cloud Computing, in 10th International Conference on Reliability, Infocom Technologies and Optimization ,Trends and Future Directions, ICRITO 2022. 2022: Noida, India

[24] Huang C, Xu C (2022) Data Mining of Students' Physical Exercise Based on Cloud Computing. Wireless Commun Mobile Comput 2022. https://doi.org/10.1155/2022/7391695.

[25] Gayathri S, Surendran D (2024) Unified ensemble federated learning with cloud computing for online anomaly detection in energy-efficient wire- less sensor networks. J Cloud Comput 13(1):49

[26] Hao Y et al (2023) Innovation strategy design of public sports service gov- ernance based on cloud computing. J Cloud Comput 12(1):69

[27] Khatoon PS, Ahmed M (2023) Design and development of dynamic Agri- ontology for IoT interoperability. Int J Commun Syst 36(11). https://doi.org/10.1002/dac.5516.

[28] Souidi E, Zouhaier L, Hlaoui YB (2022) IoT for Real-time Accessibility Ontol- ogy Population to Context-awareness Adapt User Interfaces. 2022 IEEE 46th Annual Computers, Software, and Applications Conference. IEEE, Virtual, Online, United States, pp 1462–1467

[29] Tao M (2023) Semantic ontology enabled modeling, retrieval and infer- ence for incomplete mobile trajectory data. Futur Gener Comput Syst 145:1–11

[30] Iqbal MW et al (2022) Mobile Devices Interface Adaptivity Using Ontolo- gies. Computers, Materials and Continua 71(2):4767–4784

[31] Gu MS, Hwang J, Mun H-J (2023) Design and implementation for seman- tic information retrieval through convergence of ontology and user context based on mobile device. Pers Ubiquit Comput 27(3):1123–1138

[32] Rai, S., et al., Translational Bioinformatics Ontology in Healthcare with Cloud Computing, in 2023 International Conference on Innovations in Engineering and Technology. 2023: Mulavoor P O, Muvattupuzha, India

[33] Arulkumar, V., et al., Service application model design for users using fuzzy semantic ontology model in cloud computing. ournal of Intelligent and Fuzzy Systems, 2024. 46(2): p. 3811–3826

[34] Parra-Royon M, Atemezing G, Benitez JM (2022) Semantics of Data Min- ing Services in Cloud Computing. IEEE Trans Serv Comput 15(2):945–955

[35] Tengku Asmawi TN et al (2022) Cloud failure prediction based on tradi- tional machine learning and deep learning. J Cloud Comput 11(1):47

[36] Han H et al (2024) Innovative deep learning techniques for monitoring aggressive behavior in social media posts. J Cloud Comput 13(1):19

[37] Deldar F, Abadi M (2023) Deep Learning for Zero-day Malware Detection and Classification: A Survey. ACM Comput Surv 56(2):1–37