

# IOT-Enhanced Digital Marketing Conceptual Framework

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**Abstract:** *The research proposed in this paper regards the appropriateness and possibility of enhancing digital marketing with IoT technologies. The contribution of this paper is a novel digital marketing conceptual framework based on the ubiquitous and pervasive IoT technologies, empowered by the synergies of edge, fog and cloud computing. Our proposal is grounded into the general framework of digital marketing research proposed by Kannan and Li, as well as on the comprehensive agent-based IoT paradigm, thoroughly analysed by Savaglio et al. This framework is capable to seamlessly support the emergent marketing approaches including: contextual marketing, intelligent marketing, and omniscient marketing. On the other hand, this proposal can also benefit from the techniques and methodologies for building secure and robust IoT systems that were recently proposed by Pešić et al, for increasing the security and trust of IoT-based digital marketing ecosystems.*

**Keywords:** *Digital marketing; internet of things; smart products; edge, fog and cloud computing; agent-based computing.*

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## 1. Introduction

The development of digital technologies for the global interconnection of computers through the Internet, followed by the emergence and spread of the Web as a global platform for dissemination of digital information using modern Web browsers capable of running on an unlimited variety of devices and widgets, have led to the evolution of traditional marketing towards modern digital marketing. The application of digital technologies in this process of digital marketing transformation has known several stages, from the initial emphasis placed only on the development of capabilities to transmit marketing information through interaction with consumers using digital channels, to an all-encompassing concept involving humans, institutions and processes supported by digital technologies in order to create, communicate and deliver value to marketers and consumers.

Digital marketing has grown enormously during the last decade, benefiting from the latest results and achievements in the field of digital technologies, such as: big data, artificial intelligence (AI) (including machine learning), the Internet of Things (IoT in what follows), multimedia, virtual reality and digital standards. Among the current challenges of digital marketing we mention contextual, smart, omniscient, touch-point, and integrated marketing, as well as neuromarketing (Rawnaque et al., 2020). Usually they assume the synergetic combination of several digital marketing technologies including online, mobile, social and location-based marketing.

Although the IoT concept was coined 20 years ago, it is actually related to older concepts that emerged in the area of distributed systems, including “smart device” (and later on “smart object”) to describe devices capable of smart functions, as well as “ubiquitous” and “pervasive computing” as special types of distributed computing. It is interesting to note that probably the first smart device connected to the Internet was a Coca Cola vending machine developed at the start of 80s at Carnegie Mellon University from US, providing very basic marketing functions like stock details and coke product status.

According to (Rouse, 2019), IoT is “a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.” The number of interconnected IoT devices will be above 38 billion by the end of 2025, being expected to reach 50 billion by

the end of 2030 (Tankovska, 2020), thus creating a huge network of interconnected devices using standardized Internet technologies and protocols. The availability of this massively interconnected network of devices provides unparalleled opportunities, raising also unique challenges for the digital marketing ecosystem.

IoT is one of technologies with disruptive potentials of the current century that, along with blockchain and machine learning, are expected to have disruptive impacts felt across the global economy. From the digital marketing perspective, IoT can be understood as “the interconnectivity of digital devices that provides endless opportunities for brands to listen and respond to the needs of their customers - with the right message, at the right time on the right device”. IoT is expected to impact digital marketing as follows:

- IoT enhances data-driven marketing by providing real-time customer data for service and advertising. Therefore, IoT generated data is often described as a “gold mine” for marketers, by providing abundant, richer and timely data for analytics processes. Moreover, IoT emphasizes the possibility to analyze customer buying habits and gaining deeper insights into the customer buying journey.
- IoT is an opportunity for marketers to bridge and coordinate the consumer’s physical, social and cyber worlds. The “hyper-connected consumer” empowered with IoT devices becomes a richer data source for marketing, thus enabling better context-based customization of marketing messages.
- IoT in marketing should go beyond the pure aspect of personalized messaging by focusing on end-to-end customer experience, emphasizing real-time customer engagement and optimization. IoT facilitates touch-point marketing (Lourens, 2020) by mapping customer-brand interactions over the course of the customer buying journey, helping the brand to provide the right experience for its customers across several communication channels.
- IoT in marketing enables and requires “out of the box” thinking for offering valuable services in the most accessible ways for the “real customer” in “real life” by creating a holistic, customer-centric and integrated marketing environment.

Taking into account the opportunities created by this huge potential

of IoT technologies in support to digital marketing, in this paper we investigate the suitability and possibility of extending digital marketing by seamless integration of IoT networks and devices. From this ambitious research goal, several research questions can be immediately derived.

- Does current status of development of IoT appropriately support the enhancement of digital marketing functions?
- How can we expand the conceptual framework of digital marketing to seamlessly incorporate IoT functions?

As a byproduct of answering these research questions, the main research outcome of our research endeavor can be formulated as *a novel digital marketing conceptual framework based on the ubiquitous and pervasive IoT technologies, empowered by the synergies of edge, fog and cloud computing.*

Our paper is structured as follows. After setting up the context and the motivation for our work, we follow in Section 1 with a brief review of related works, mainly focusing on the conceptual background of digital marketing, IoT technologies and their business adoption. Section 2 introduces our research methodology that is conceptually and technologically grounded in some of the most recent advances in the field. Section 3 discusses our results using a relevant set of use cases, serving also as qualitative evaluation of our proposal. The last section summarizes our achievements and points to future works.

## **2. Review of the Scientific Literature**

There is very large body of recent literature that is relevant for various aspects of digital marketing and IoT technologies. Doing an all-encompassing review of these areas is far beyond the declared scope of our paper. Nevertheless, we selected for a brief review only a few works that we appreciated as being highly relevant for our own research. The state-of-the-art review is structured according to the most relevant topics of concern for the proposed research.

### ***2.1. Digital Marketing***

Throughout the short history of digital marketing, digitization and automatic processing of marketing data have gone through several stages of transformation and evolution. Each stage contributed to the transformation and expansion of the field and role of the marketing function within an organization.

Based on the analysis of the historical evolution of data-driven

marketing (Shah & Murthi, 2020) propose a decomposition of this process into five stages. Each stage describes how data-driven applications supported by digital technologies were influenced by the business environment and technological advancements at that stage, and how this ultimately contributed to expanding the role and scope of marketing within an organization.

- The pioneering stage. It emerged in the early twentieth century highlighting the importance of data-driven marketing applications for the better management of creation of meaningful content for consumers.
- The customer-centric stage. As the importance of marketing has increased over time, in the second half of the twentieth century, we are witnessing the highlighting of the relevance of marketing for a company's business practices. From a data perspective, marketers have begun to better focus on collecting and analyzing customer transaction data on: “which” customer bought “what” product / service “when” by capturing this information in customer databases, over time. This trend of research and marketing practices can be characterized as strongly customer-centric.
- The rich data-driven stage. In the early 2000s we are witnessing an explosion of data that fundamentally changed the way the marketing function was performed within an organization. The rapid penetration of the Internet, the proliferation of smartphones and the increasing use of social platforms has led to the generation of an unprecedented volume of digital data. As this volume increased, marketers adopted advanced statistical modeling techniques to analyze increasingly complex customer-level data. In addition to traditional transaction data, it also included unstructured data in the form of digital conversations, pictures, videos, audio and video files obtained from digital and social media. A direct consequence of these transformations was that the marketing function evolved more as a science than as an art. Moreover, because the flow of information and transactions have been greatly facilitated by the development of the Internet, the analytical capacity has greatly improved the company's ability to engage in individual marketing by creating personalized content and directing correct price offers to customers.

- The financially responsible stage. At the beginning of the 21st century, the marketing function faces a new challenge. Thus, a lack of responsibility in marketing was perceived, which diminished the credibility of marketing, threatening both the positioning of the marketing function within the company, as well as the existence of marketing as a discipline. Marketing research has reacted by associating the consequences of marketing efforts with data on the financial outcomes of a company. The overall purpose of these studies was to quantify the extent to which marketing significantly influenced performance at the firm level. Such results have strongly contributed to establishing the financial responsibility of marketing efforts and, therefore, to further expanding the general scope of marketing within an organization.
- The digital disruption stage. We are currently witnessing an era of digital disruption that is causing an unprecedented leap in companies of various industries. Marketing research is profoundly transformed by new marketing practices supported by information and communication technologies such as: artificial intelligence, mixed reality (virtual and augmented, i.e. enriching the real world by combining elements of physical and virtual reality with digital artifacts) and blockchains based on secured decentralized peer-to-peer distributed databases. Marketing practices are now embracing more and more other technologies with disruptive potentials, such as the IoT and socio-cyber-physical systems.

## ***2.2. IoT Technologies and Their Business Adoption***

The IoT brings together physical and digital worlds through a network of interconnected devices using standardized hardware and software interfaces. The IoT applications have unbounded possibilities in virtually any socio-economic area, being only limited by the human imagination and creativity.

Currently we are experiencing a technological diversification of various computing paradigms emerging from network and distributed computing that are supporting the development of IoT ecosystems. Modern IoT infrastructure is strongly grounded into the most recent advances of computer networks and distributed systems technologies represented by the emergent mobile, edge, fog, cloud, and related computing paradigms (like

for example mobile edge computing and mobile cloud computing).

Cloud computing is providing convenient on demand service-oriented access to virtualized IT infrastructure, platforms and applications to individuals and organizations, via Internet. Cloud computing is the current standard for securely storing and heavyweight processing of IoT-generated data on multiple remote servers, while having immediate access to it from multiple devices, anytime, anywhere.

Edge computing is a distributed computing model in which computing power and storage capacity are situated as close as possible to the location where they are needed, thus improving response time and saving communication bandwidth. Edge computing can be described as computing that is performed outside the cloud domain, as close as possible to the "network edge". Edge computing includes IoT systems composed of interconnected devices of low computing power that generate lots of data that are usually stored and processed in cloud data servers.

Fog computing refers to computing, storage and network services that are located between the edge and the cloud. Thus the fog represents an intermediate level that offers an average computing power, usually provided by local decentralized servers. Its role is to take over part of the processing and communication between the edge and the cloud, but closer to the edge level.

Mobile computing is a distributed computing paradigm that is applicable to all programmable, portable, wireless, and conveniently held devices including, but not limited to, tablets, pads, smartphones, laptops, and various types of wearable devices (Elazhary, 2019). Typical smartphones are nowadays equipped with many embedded sensors (e.g., GPS, accelerometers, gyroscopes, RFID readers, cameras, and microphones) along with different communication interfaces (e.g. Cellular, WiFi, Bluetooth), thus acting as veritable providers of sensory data in the IoT ecosystem (Al-Turjman, 2019).

Throughput and latency requirements of IoT systems can vary, thus requiring flexible storage and processing architectures based on innovative combinations of edge, fog and cloud computing that are part of IoT-enabled digital marketing ecosystems.

The Economist Intelligence Unit's "Internet of Things Business Index" (EIU-IoT-BI) represents probably the most accurate global measure of the commercial implementation of IoT technologies. The index is determined using a global and cross-industry executive survey. The 2020

edition shows that during the last three years, a significant leap in IoT adoption took place (EIU, 2020). The findings revealed that this progress is also reflected by the increased investments that delivered returns for some of the respondents. Companies agreed that a path to IoT business value has been identified. A crucial aspect in this direction is the use of IoT data strategically, in particular the use of AI to valorize IoT data. However, security, privacy and trust were recognized as very important issues still hindering IoT adoption at its full speed.

While broad in scope, the EIU-IoT-BI carries also few specific outcomes that we found directly relevant for the digital marketing domain. First note that the possible values of this index score are: 0-2 (non-existent), 2-4 (in-research), 4-6 (in-planning), 6-8 (early-implementation), and 8-10 (extensive). As such, IoT global adoption in the products and services sector is in incipient early-implementation stage (score 6.12). In consumer good and retail industry (directly relevant to digital marketing), IoT adoption is in incipient early-implementation stage as concerning internal operations, and in late in-planning stage as concerning products and services (score 5.44). Very interesting are also the figures concerning the applications of IoT data. For example, between 33% and 48% of the respondents confirmed the adoption of IoT data analytics for product and process optimization, as well as for operational and strategic decision making. Moreover, 37% of respondents confirmed that customer service and support benefitted from IoT data management and analysis adoption. Finally, 87% of respondents recognized security threat as a major issue of IoT adoption, confirming the use of internal and external expertise and resources to deal with this aspect. It is worth noting that 9% of the respondents declared that the primary industry of their organization is consumer goods and retails. Moreover, 7% of the respondents declared marketing and sales and other 7% of the respondents declared customer service as their main functional role in their organization.

(Caro & Sadr, 2019) show that IoT plays a fundamental role for channel integration in omnichannel retailing, by allowing companies to rebalance supply and demand. A classification of IoT initiatives based on an opportunity map, by distinguishing them based on the value they create and by their area of impact, is proposed in that work. IoT adoption is justified in terms of its enabling capabilities, either immediately achievable by deploying IoT sensor data or by its enhanced capabilities resulting from the unanticipated benefits following IoT adoption, within the interaction of

supply with demand.

Jabbar et al. (2020) address real-time big data processing for supporting instantaneous marketing decisions. The processing workflow of such large datasets for real-time decision raises new challenges for marketing organizations. This work proposes interdisciplinary dialogues that overlay software engineering frameworks within marketing viewpoints, as well and their implications for current marketing practices.

Vasiljević, et al. (2019) propose the design and experimentation with an IoT Infrastructure for neuromarketing research. Arthmann & Li, (2017) analyze the possibilities opened by IoT technologies to study consumers' sensorimotor, cognitive, and affective response to marketing stimuli. Such technologies comprise: i) Functional Magnetic Resonance Imaging (fMRI) to detect activity changes in the “pleasure center” of the brain; ii) Electroencephalography (EEG) and Steady State Topography (SST) to quantify brain electrical activity that decode motivation and cognitive load; iii) biometrics sensors to quantify changes in the physiological state (e.g. heart rate, respiratory rate and galvanic skin response); iv) motion tracking for eye movement to identify focal attention, and facial coding to classify the physical expression of emotion. A more systematic review of the current technological advancements and opportunities in neuromarketing is introduced in Rawnaque et al. (2020). The trends and advancements in neuromarketing were categorized as follows: i) utilized marketing stimuli; ii) activation of the brain regions due to marketing stimuli; iii) neural response recording techniques; iv) brain signal processing; and v) machine learning applications.

A review of IoT support for marketing activities was proposed in (Taylor et al., 2020). According to this review, IoT support for marketing activities is materialized as: i) data available from IoT devices; ii) IoT data analytics; and iii) communication channels with owners of IoT devices. This work also proposes a preliminary framework for IoT enhanced marketing, comprising: customer relationship management, IoT business intelligence, and IoT support for new product design. Although similar in goal with our own work, our proposal offers a considerably deeper insight into the design of a new conceptual framework for IoT-enhanced digital marketing. In particular, we highlight the value of a layered architecture focused on smart product management and coupled with an agent-oriented modeling approach, while also recognizing the need of incorporating a sound security and trust analysis framework.

### 3. Research Methodology

Our research methodology is based on a constructive approach grounded into the most recent theoretical and practical developments in the fields of digital marketing and IoT. Constructive research aims at producing novel solutions comprising both practical and conceptual approaches (Oyegoke, 2011).

Following this proposed approach, the development of our IoT-enhanced digital marketing conceptual framework is theoretically grounded into core conceptual foundations of marketing research including: i) marketing mix (McCarthy, 1960, p.45), ii) set of generic marketing tasks (Kotler & Keller, 2016, pp. 49-50), and iii) general framework of digital marketing research (Kannan & Li, 2017), as well as technically grounded into: i) comprehensive agent-based IoT paradigm (Savaglio et al., 2020) and ii) CAAVI-RICS modeling of secure distributed IoT systems (Pešić et al., 2020).

Our proposed research methodology follows three steps:

- A convergence analysis of current conceptual frameworks of digital marketing with state-of-the-art IoT technologies, to address the first research question.
- The design of a new IoT-enhanced conceptual framework for digital marketing, thus addressing the second research question.
- The qualitative evaluation of our proposal based on a theoretical investigation of several hypothetical use cases, serving as validation step of our research results.

#### *3.1. Enhancing Digital Marketing with IoT Systems*

The term marketing mix was introduced by McCarthy in (1960, p.45) to describe the most important activities in marketing management. This model specifies four major levels of marketing decision: “product, price, place, and promotion” being known in the literature as the 4P model. This model is also promoted by (AMA, 2014).

The 4P model was later adapted and extended to conceptualize other various decision-making perspectives in marketing management. Some examples are: the modern 4P model: “people, processes, programs, and performance”, the 4C model: “consumer, cost, convenience / channel, and communication”, the 5C model: “customers, collaborators, competitors, context, and company”, the 4A model: “acceptability, affordability, accessibility, and awareness”, the 7P model by extending the 4P model with

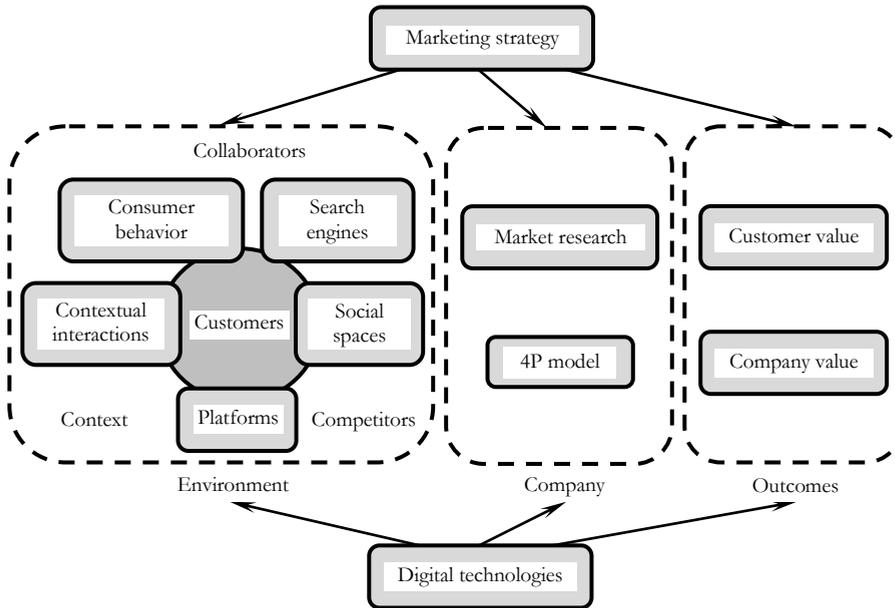
other 3 dimensions: “process, people, and physical evidence”, respectively the 8P model by extending the 7P model with the “performance” dimension.

The common element of all these abstract marketing mix models is the identification of a set of types of generic tools that an organization can use to achieve its marketing objectives. Kotler and Keller complemented this by proposing in (2016 pp. 49-50) a set of generic tasks that can lead to a successful management of an organization's marketing:

- Development of marketing strategies and plans.
- Acquisition of detailed marketing information.
- Connecting with beneficiaries.
- Building strong product brands.
- Creating value.
- Value delivery.
- Communicating value.
- Responsible marketing for long-term success.

On top of that, (Kannan & Li, 2017) proposed a general framework for scientific research in marketing starting from the conceptual model of the 5C: “customers, collaborators, competitors, context, and company”. All these elements designated by C together with the classic 4P marketing mix are incorporated into this framework, but grouped differently and expanded with new elements. Thus, according to Figure 1, the components of this framework are:

- Marketing strategy
- Marketing environment
- Company
- Marketing outcomes
- Digital technologies



**Figure 1:** Digital marketing research framework adapted from (Kannan & Li, 2017)

Customers represent the focal element of the marketing environment, next to which we find: context, competitors and collaborators. Emerging concepts, interactions and structures in relation to customers include: digital platforms, consumer behavior, search engines, social spaces (including social media and user-generated content), and respectively contextual interactions. All these are inputs processed by the company's marketing function, defined by marketing research and analysis on the one hand, and the marketing mix (4P model) on the other. On the right-hand side in Figure 1 we find the results of marketing actions and strategies, materialized in the overall impact of digital technologies on value creation:

- Customer value: value equity, brand equity, relationship capital, consumer satisfaction, and customer lifecycle value.
- Company value: sales, profits, growth rate, and customer equity (customer acquisition and retention strategies, as well as higher profit margin, respectively).

The main idea of our proposed framework is to identify and highlight the possible enhancements that can be brought by IoT to consumers and products, that represent in our opinion the core elements of

any marketing (digital or not) campaign. In particular, the customer-product and customer-brand interactions are now becoming the focal elements of the IoT-enabled marketing platform. These elements will then be mapped to the general framework of (Kannan & Li, 2017) that represents the state-of-the-art in the field.

The central element of our proposed framework is an *IoT-enhanced smart products platform*. Smart products are defined as products augmented with digital capabilities of some sort to support IoT integration, including for example products with tags and connectible products. The range and number of smart products are expected to massively explode during this decade, taking into account the falling costs of supporting digital technologies (Davies, 2015).

Product tags represent information attached to products to facilitate their management including description, classification, organization and tracking during their lifecycle stages (manufacturing, supply-chain, warehousing, in-store selling, and consumption). Examples of state-of-the-art tagging technologies are: Radio-Frequency Identification (RFID), Near Field Communication (NFC), barcode, smart packaging, Quick Response (QR) code, beacons, image recognition, and Electronic Product Code (EPC). Tags are digitally encoded such that they can be automatically read and interpreted by specialized digital devices, and the resulting information can be fed into the IoT platform for further processing and analytics.

The technology of smart connectible products is made possible by the recent progress in computing, device miniaturization, and ubiquitous interconnectivity. The smartness of connectible products is conveyed by their enhancement with hardware, sensors, data storage, processing power, connectivity, and software capabilities in so many ways (Porter & Heppelmann, 2014).

Smart connectible products have three core layers: physical layer, smartness layer, and connectivity layer. The core functions of the product are conveyed by its physical parts (mechanical and electrical) that are embedded in its physical layer. The smartness layer comprises hardware and software digital artifacts including sensors and processing units, as well as system and application software. Examples include: i) hardware: Raspberry Pi, Arduino, Intel, ARM, Freescale, and Texas Instruments; ii) system software: Nucleus RTOS, Amazon FreeRTOS, Windows 10 IoT, Wind River VxWorks, and TinyOS. The connectivity layer comprises external interconnectivity ports based on networking protocols. Examples are: i) wireless protocols: IEEE

802.15.4 (ZigBee), IEEE 802.11 (Wi-Fi), IoT SIM card, and Bluetooth Low Energy (BLE); ii) wired protocols: Constrained Application Protocol (CoAP), WebSockets, Representational State Transfer / Hypertext Transfer Protocol (Rest/HTTP), and Message Queuing Telemetry Transport (MQTT). According to (Porter & Heppelmann, 2014), smart connectible products have various capabilities that can be structured as layered functionalities, in increasing order: monitoring, control, optimization, and autonomy.

As one can notice, IoT devices for smart products are highly heterogeneous, requiring a high integration overhead. This effort can be reduced by developing standardized meta-models based on semantic representations, to describe the semantics of IoT components independently of their operational specifications (Charpenay et al., 2015), (Ganzha et al., 2017).

A key element of our proposal is to facilitate the customer-product and customer-brand interactions through the development of social IoT empowered by 5G technologies, as well as advanced interaction capabilities based on advanced technologies such as gesture and speech recognition. This can be achieved by social space services provisioning enhanced user interfaces.

Social space services can provide user's identity and personal information, location and time information, relevant to the situation or activity the user is currently involved in, as well as the most relevant services in the form of a Space as a Service (SpaaS) smartphone mobile cloud application, adaptable to the user's profile (Al-Turjman, 2019).

Human-device interaction in IoT can be also improved by seamless adoption of natural language interfaces based on speech recognition, beyond the limited interfaces provided by the device manufacturers (Rubio-Drosdov et al., 2017).

In what follows we examine the updated components of the general framework proposed by (Kannan & Li, 2017), addressing their envisioned enhancements with IoT technologies and their impact to novel marketing functions.

Consumer behavior studies how individuals, groups, and organizations select, buy, use, and give up goods, services, ideas, and experiences to meet their needs and desires. Consumers equipped with 5G-enabled mobile computing devices engaged in highly contextualized interactions with smart products and brands, as well as with other customers

and digital services in smart social spaces, are generating by far larger and richer amounts of real-time data than ever before. More detailed and accurate determinants of cultural, social, personal, and psycho-emotional factors of consumer buying behavior, like for example factors related to neuromarketing (Arthmann & Li, 2017) are now promptly available to marketers for operational and strategic decisions, enabling end-to-end customer experience optimization.

Dynamic smart social spaces together with space discovery services enable highly contextualized interactions with digital services (for example search engines, digital ads, and content sharing networks) and platform markets, taking into account user emotions, location, time and current needs. They will strongly impact the identification and assessment of: customer trust and risk perceptions, dynamics of electronic Word-of-Mouth (eWOM) (Babić et al., 2016), influencers, impact of competitors, as well as effects of geographical location, region and culture.

It can be observed that our proposal mostly influences the “product” P from the 4P model shown Figure 1. According to (Porter & Heppelmann, 2014), IoT-enabled smart connected products provide a new taxonomy of key functionalities, strongly impacting corporate strategies and requiring hard strategic choices. For example, successively adding smartness and connectivity layers to a given core product can attractively result in far smarter products that might change industry and competition boundaries with dramatic and risky consequences on the business itself, while on the other hand this kind of enthusiastic expansion requires careful thinking and rational business decisions, before its adoption and implementation.

According to (Kannan & Li, 2017, p.37), there is scientific evidence that online customer interaction, eWOM, as well as consumer and firm-generated online content can directly impact marketing outcomes, in particular company sales, as well as individual customer purchases in and across product categories. Taking into account that our proposal diversifies and widens online interactions across time and space by enrolling IoT devices and networks, we have reasons to believe that it will have a stronger impact on marketing outcomes, requiring a more careful examination. This is an interesting research question for a deeper and more focused investigation.

### ***3.2. IoT-Enhanced Conceptual Framework for Digital Marketing***

In this subsection we follow a constructive approach by proposing a layered framework of our IoT-enhanced platform for digital marketing, focusing mainly on the conceptual elements underlying the IoT-based digital

technologies that actually detail the “Digital technologies” component of the (Kannan & Li, 2017) framework shown in Figure 1. On one hand, this provides an answer to our second research question, while on the other hand it represents a clear research outcome of our work.

Our framework is illustrated in Figure 2. It is structured into 3 nested layers and 1 extra layer, as follows:

- Core layer is represented by the *IoT-enhanced smart product platform* that constitutes the kernel of our framework. This layer mainly resides in the cloud. However it may also contain fog components that mediate the load balancing and optimization of the interactions between IoT edge devices and the cloud.
- Mid layer is represented by the *CAAVI-RICS security model*. Note that CAAVI-RICS is not a technological solution. Rather, CAAVI-RICS helps us to explore and understand the credibility, authentication, authorization, verification, and integrity of IoT systems through explaining the rationale, influence, concerns and security solutions that accompany them, thus being able to incorporate the plethora of technological solutions for building secure and robust IoT systems (Pešić et al., 2020). The aim of this layer is to increase the security and trust of IoT-based digital marketing ecosystems built around our conceptual framework, which is seen of crucial importance for the credibility of our approach.
- External layer is represented by the *agent-based model*. This layer is not necessary a strictly technological layer, although technological solutions based on agent middleware are possible (Bădică et al, 2011). Agent-based computing paradigm is based on the agent software abstraction defining an autonomous, situated, social, reactive and proactive computational entity. Agents are not isolated entities. Rather, they form multi-agent systems representing ensembles of agents, which interact and cooperate in distributed and self-steering societies with well-defined organizational relationships (Savaglio et al., 2020). In particular, the agent-oriented approach allows us to model the digital marketing ecosystem through multi-agent systems.
- Extra layer includes heterogeneous actors representing business applications, smart products and smart consumers that interact to achieve their personal and business objectives, either directly

or indirectly via the platform. Business applications support the business actors of the platform, including for example: stores, manufacturers and brands. Smart products represent products enhanced with IoT capabilities. Smart consumers represent consumers equipped with 5G mobile and wearable devices. Each actor is represented in the system by a suitable agent. For example smart products can be represented as agents incorporating smart objects (Savaglio et al., 2020). Smart consumers can be represented using personalized agents, while business applications can be conceptualized as business agents (Bădică et al., 2016) of various granularities, depending on their specific requirements.

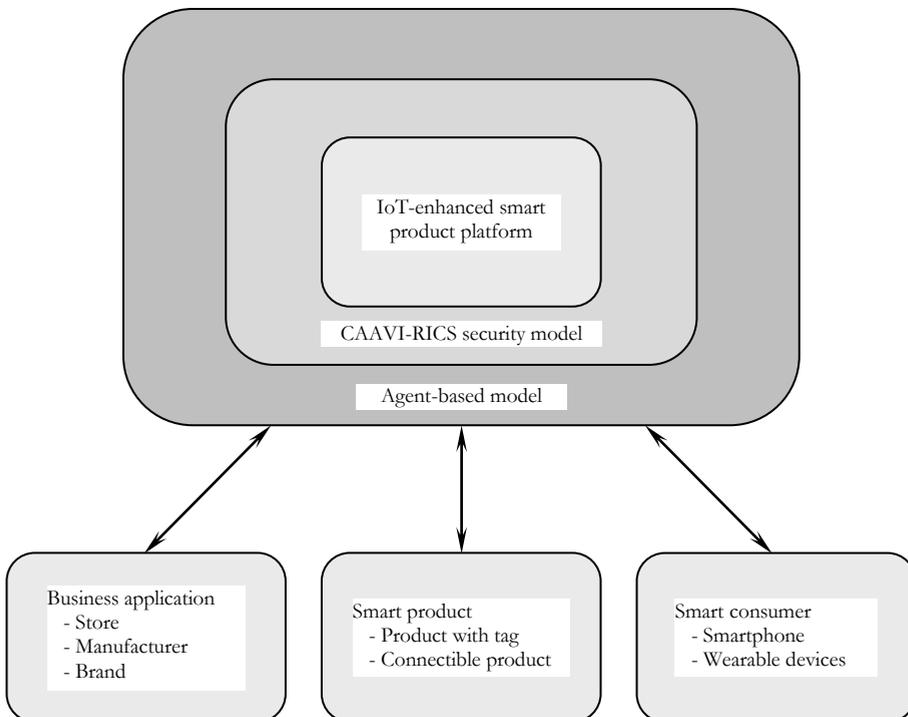


Figure 2: IoT-enhanced digital marketing conceptual framework

Source: Kannan & Li, 2017

#### 4. Results and Discussion

In this section we emphasize the generality of our proposal, by

outlining few convincing use cases that can be structurally and functionally mapped to our proposed conceptual framework. In this way, they will support the qualitative evaluation of our proposal, thus validating our work.

#### ***4.1. Smart Products as Media Carriers***

Once activated, products enhanced with smart tags can trigger actions onto a data-driven, owned media platform to launch personalized digital experiences and content, thus engaging in one-to-one consumer relationships. A media-enhanced product can use our IoT-enhanced digital marketing platform to let consumers virtually interact with the products using smart tags and mobile devices. For example: i) consumers can personalize a product by associating to it personalized or contextualized multimedia messages that can be visualized during the virtual interaction with the product (for example, via a smartphone); ii) consumers can be incentivized with loyalty points for interacting with the product in smart trading locations and environments; and iii) products can be tracked across the supply chain to improve logistics and operations.

#### ***4.2. Smart Appliances***

IoT-enabled smart appliances are programmable connectible appliances that can be used to implement various IoT scenarios. One example is the virtual dash button, an IoT-enabled smart button that implements a form of frictionless shopping. The smart button can use the local network to link to the e-commerce app via our proposed platform, thus allowing customers to automatically order products when they are running low. For a good overview of IoT-enabled smart appliances, including the AWS IoT example of smart button (Amazon, 2020), the reader is invited to consult reference (Aheleroff et al., 2020).

#### ***4.3. Autonomous Retail***

Autonomous retail is expected to change how people perceive and engage in shopping. Autonomous stores empowered by the services provided by our proposed platform can provide the following benefits: convenient 24/7 and frictionless operation (e.g. checkout and queuing free shopping), finding and locating products in-store, real-time stock monitoring and more accurate understanding of human shopping behavior. Automated retail technologies are based on IoT-enabled devices and systems, including: video cameras inside the store, 3D position readers of all persons inside the store, weight sensors on the shelves, and counting sensors for persons

entering and exiting the store.

#### ***4.4. Brand-Customer Interaction in Social Media***

Brands are usually interested to ask their customers to post something good about them in social media. However, most often such requests are not so intensely served, unless the customer is incentivized by getting something in return. Using our proposed IoT-enabled smart platform, a social media hash-tag can connect to product promotions and giveaways. The brand can randomly select users (or perceived influencers and opinion leaders) to be rewarded with a product, as they tweet or post a particular hash-tag or on a specific channel.

#### ***4.5. Print Advertisements Enhanced with IoT Technology***

Print advertisements may be combined with IoT technology in our proposed smart platform to convey value to the users in an innovative way. For example, print advertisements can offer bracelet strips that users could peel off and put on their children's wrists or on their pet's neck. The bracelets are endowed with built-in locators, which, with the help of a mobile app and platform's location services, allow users to configure and track their children or their pets wandering around.

#### ***4.6. Brand Teaming***

Brands can team up with the help of our smart platform to create more enjoyable and seamless experiences for their users. For example, a music streaming brand can team up with a taxi company. Users will be able to connect their music account to the taxi app such that when they get in a taxi, they can use their taxi app to automatically play their preferred music soundtracks through the car's speakers. Similarly, a fitness tracker can offer contactless NFC terminal payment in combination with a mobile payment service, while a card company can team up with a car brand and user's preferred restaurant to enable in-car voice-activated booking, menu ordering and payment.

Brand can also improve their customer experience by involving in data partnerships in the context of IoT-enabled digital marketing. For example, two different brands could have each either a broader or respectively a deeper understanding of the customer base. Therefore, their data partnership can produce a more holistic view of the customers. For example a car manufacturer can partner to a telecommunications company by integrating more 5G technology into their vehicles. Together they can

deliver a better user experience by sharing live journey data, occupancy status and road conditions gathered by in-car sensors.

Such partnerships between brands create ecosystem-connected products that undoubtedly will improve the customer experience, which will also likely lead to longer-term customer retention.

#### ***4.7. Smart Product Integration with Customer Daily Experiences***

Our IoT-enabled smart platform has the potential to seamlessly improve the brand's products and services by diversifying and deepening their integration with the customers' daily experiences. This will highlight the brand's innovation and uniqueness, thus increasing the efficacy of the marketing strategy. For example, a car brand can provide an in-car e-commerce platform allowing drivers to order and pay for their favorite coffee-shop drinks and treats, book dinner, and locate the closest gas station from the dashboard touchscreen.

### **5. Conclusions**

Based on a thorough analysis of the current trends in digital marketing and IoT technologies, we have investigated the appropriateness of IoT enhancement of current digital marketing conceptual frameworks. Then we have proposed a novel conceptual framework of IoT-enhanced digital marketing. The framework is grounded into a comprehensive conceptualization of digital marketing research, a sound security analysis model for IoT and edge computing systems, as well as an agent-oriented modeling approach. The framework is structured into 3 nested layers and 1 extra layer: i) core layer representing an IoT smart product platform; ii) mid layer represented by the CAAVI-RICS security model; iii) external layer represented by the agent-based model; iv) extra layer comprising actors representing business applications, smart products and smart consumers. The framework was discussed and qualitatively evaluated by proposing few prototypical use cases in the area of IoT-based digital marketing. Interesting future research directions are: i) deeper and more focused investigation of the impact of IoT-mediated online interactions onto marketing outcomes; ii) evolving our conceptual framework towards the more detailed design of an IoT-enhanced architecture for digital marketing grounded into the most recent developments in mobile, edge, fog, cloud, and agent computing; iii) enhancing our framework with conceptualization of business intelligence functions based on artificial intelligence advances.

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