

## Article

# Internet of Vehicles Empowered Mobile Media: Research on Mobile-Generated Content (MoGC) for Intelligent Connected Vehicles

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**Abstract:** With the rapid growth of mobile media, large quantities of mobile content have been generated by moving entities. Some content generation patterns become popular for users and professional organizations, e.g., user-generated content, professionally-generated content, machine-generated content. However, due to the limitations of device types and functions, it is necessary to explore the new production tools and further inspire the content potential in mobile scenarios. According to the production capacity supported by Internet of Vehicles, intelligent connected vehicles (ICVs) emerge as new content generated devices in sustainable cities. In this paper, we propose the concept of Mobile-Generated Content (MoGC) as a new part of production patterns. First, we analyze the relationship between MoGC and existing patterns from the perspectives of entity and workflow. Second, the unique functionality and social property of MoGC are revealed, i.e., ICVs play the role of middle platform with data and technology offices. The current dominant discourse created by the professional institutions (e.g., media agency or governing authority) will transfer to the vehicle users. In this way, the content generation system has been further enriched in omni-media environments through efficiently integrating productivity tools and resources. Besides, MoGC not only contributes to social governance by enlarging the news source and coverage, but also strengthen the personal discourse in mobile scenarios.

**Keywords:** mobile media; internet of vehicles; intelligent connected vehicles; mobile-generated content; mobile middle platform



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## 1. Introduction

In recent decade, along with the prosperity of social media applications and e-commercial, e.g., instant messaging, streaming media services, and mobile payment, the number of mobile users and data traffic is dramatically increasing as shown in Table 1. As estimated, the amount of global mobile devices would reach 13.1 billion by 2023, which increases about 49% compared with 2018 [1]. Especially, each hundred people own 113.9 mobile phones on average in China [2]. The users daily time spent on mobile devices (e.g., smartphones, tablets, and e-reader etc.) is 3.67 h, which grows 35% from 2017 to 2019 in the world [3]. We can see that the mobile media era has already been coming.

**Table 1.** Statistics of mobile Internet in 2014 and 2020.

Statistics Item	Year	Global	China
Mobile subscribers (Billion)	2014	2.6 [4]	0.8 [5]
	2020	7.9 [6]	1.3 [2]
Mobile data traffic (EB/year)	2014	39.6 [4]	1.9 [5]
	2020	612 [6]	154.2 [2]

### 1.1. Pros and Cons of Mobile Media

The prosperity of mobile media attributes to advanced wireless communication techniques [7]. Moving entities (e.g., devices, persons) can exchange and disseminate public or personalized multimedia information among connected users [8,9]. The advantages of mobile media can be summarized as follows:

- **Real-time communication:** Relying on the mobility property, mobile devices support real-time interaction regardless of time and location [10,11] and enable users to conveniently switch between physical and digital spaces. As a result, the boundary between public and private areas is eliminated. After receiving messages, mobile users can react and feedback their attitudes as quickly as possible [12].
- **Portable infotainment center:** As multimedia dissemination tools [13–15], mobile terminals have become the personal infotainment center. Users can do various operations via applications, such as creating and archiving content [16], playing games, taking pictures, and staying active on social media [17].
- **Social relationship's promoter:** The mobile media strengthen the personal ties by connecting individuals to the society [18], which can expand social networks and influence interpersonal relationships among mobile users [19]. As a result, mobile media turns to be an important facilitator of social relationships for users [20].

As a new type of media, mobile media not only changes the public space [19] and human behaviors [21], but also deeply affects communication forms [9]. Compared with the age of mass communication, additional channel or platform is provided to distribute the generated content either from institution or user side. Specifically, mobile media tools begin to determine the workflow of news production, presentation, and consumption [22]. But, there exist some limitations of mobile media, summarized as follows:

- **Types of mobile devices:** Although mobile media has already penetrated into the areas of social contact, news [23], game [24], music [25], and E-learning [26], smart phones are the dominant carriers to support those functions [27]. In recent years, tablets and wearable kits (e.g., Apple watch and wristband) have emerged [28,29], but most of them still restrict to tiny smart devices. Some mobile entities with large size and high media value are not yet fully exploited for communication.
- **Functionality of mobile media:** The role of mobile devices is not only to present or disseminate information, but also a suitable tool for content production [30], e.g., tweets, pictures, short videos, etc. However, considering different production capacities among mobile tools, we need to develop new production patterns to boost the functions of mobile media and then satisfy the social requirements in mobile scenarios.

### 1.2. Mobile-First Strategy

Considering the explosive growth of mobile media, Luke Wroblewski advocates the concept of “mobile-first”, which aims to develop mobile services prior to web applications. By this way, the user mobile experience is enhanced and meanwhile new opportunities can be created for the Internet companies [31]. Afterwards, the “mobile first” strategy is widely adopted. For the Internet giants, Google recognizes the importance of mobile devices and puts higher priority to develop mobile services than that on desktop PC applications [32]. Facebook adopts the “mobile-first” strategy to create video advertizing, which intends to lift the brand by increasing users’ mobile content consumption experience [33]. PayPal

develops the mobile-first payment platform and show that the mobile commerce grows fast than the e-commerce in Canada [34]. IBM deploys mobile-first platform to help organizations with the effective developing, testing and managing of mobile applications [35], etc. China has proposed a series of “mobile-first” policies from the state-level since 2019, which aims to enhance media integration by using mobile media. The policy issued in 2019 clearly refers to the “mobile-first” strategy. The mainstream media should prioritize to use mobile media for correct guidance of public opinions, heritage cultures and serving the public [36]. The “mobile-first” strategy is recognized as the pivotal solution to accelerate media integration in depth. Therein, it is necessary to improve the content generation & distribution system with high efficiency [37], which puts forward higher demands for the mobile media.

Apart from the Internet in the era of Web 2.0, the Internet of Vehicles (IoV) has emerged as an outlet which can merge the traditional media (e.g., television, radio) and social media (e.g., infotainment applications). The evolved cognitive IoV architecture is proposed to further enhance the functionalities of intelligent cognition, control, decision-making and security in autonomous driving scenarios [38,39]. The intelligent connected vehicles (ICVs) become a platform to create and offer content for the consumers. Apart from mobile phones, we believe that the ability of ICVs will pave the way for the “mobile-first” strategy and contribute to the prosperity of mobile media.

### 1.3. Contribution and Organization

In this work, exploiting the capability of ICVs, we study new content-generated pattern in mobile scenarios and reveal the unique characteristics compared with the existing patterns. The contributions of this paper are summarized as three-fold:

- First, we propose the notation of Mobile-Generated Content (MoGC) aided by ICVs, which differs from the existing content generation patterns, e.g., user-generated content (UGC), professionally-generated content (PGC), and machine-generated content (MGC). Through integrating MoGC with UGC, PGC and MGC, the content-generated system is enriched and suitable for omnipresent media environments.
- Second, the elements, application areas and interactive targets of MoGC are described by modified Lasswell’s model with feedback. Moreover, the relationship in content-generated system is revealed through investigating the links between MoGC and the existing patterns in terms of participant entities and production workflow.
- Third, we figure out the features of MoGC from the perspectives of function and social properties: (1) ICVs become mobile middle platform consisting of data and technology offices, which serve for the production of news and public-interest content; (2) The discourse in mobile scenarios gradually transits from legacy news to in-vehicle infotainment (IVI) users. The diversity of mobile news tends to increase rapidly and facilitate the citizen journalism, which help the social governance and enhance the personal discourse.

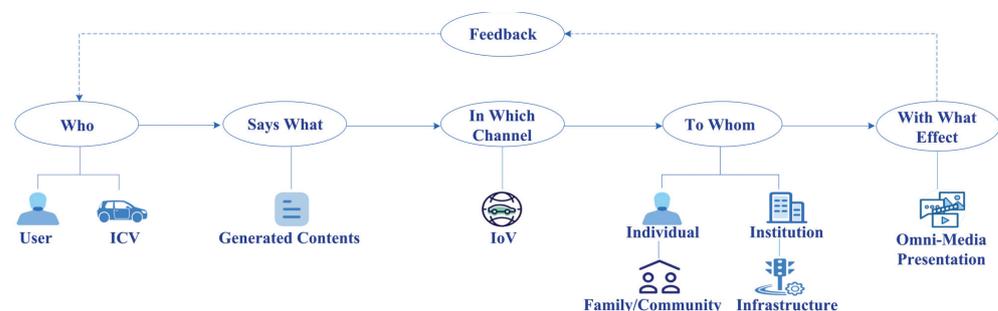
The rest of this paper is organized as follows: Section 2 clarifies the elements of MoGC and then reveals the common characteristics between MoGC and the existing content generation modes. Section 3 illustrates the unique properties of MoGC. Section 4 concludes this paper.

## 2. The Positioning of MoGC

MoGC pattern utilizes moving entities (e.g., ICVs including the types of passenger/commercial vehicle, train and subway) to participate and take responsibility in data collecting, news editing, and content generation in mobile media scenarios. It is worth noting that the streamline vehicle using by legacy media is just a special case of MoGC. In this paper, we discuss the content production of IoV empowered vehicles in general. Especially, ICVs can be regarded as giant mobile tools for MoGC and then create new impetus for content production in sustainable cities. The reasons can be summarized in three aspects:

- Closer relationship with vehicles: as large mobile terminals, ICVs can support the functionalities of in-vehicle payment, social, and office, etc. The abundance of IVI continues to inspire the needs of drivers and passengers in the cabin. Moreover, those trends directly help IVI users approach closer to vehicles, which gradually become the intimate friend during the traveling.
- Wide usage of infotainment system: infotainment systems have become popular and standard parts in automobiles, which enable drivers and passengers to access abundant applications via IoV for commuting and traveling. The infotainment habits have been developed and interactive media outputs gradually sprout, e.g., social sharing. It is necessary to extend the functionality of vehicle systems to satisfy the needs of occupants in mobile scenarios.
- Nascent content generation capability: equipped with various kinds of sensors (e.g., cameras, radar), ICVs have tremendous potentials for content production any time any where, where the data collection and process capability exceeds existing mobile devices (e.g., smart phones). The role of ICV can be transformed from the IVI and resource sharing centers [40] to the producers of media content.

In Figure 1, the modified Lasswell's model with feedback is used to clarify the elements, application areas and interactive targets of MoGC. In mobile scenarios, according to the demands of entities from inside and outside cabin, ICVs and users exploit the IoV-based vehicular platform to generate and distribute the desired content for target audiences, which include the individuals, institutions, family, community and even the transport infrastructure. Thereby, the omni-media presentations can be realized by covering the related applications and scenarios. The user experiences (or requirements) of the content will feedback to creators for the propose of enhancing the quality of MoGC and satisfying the needs of target users and institutions.



**Figure 1.** The elements of Mobile-Generated Content (MoGC) in modified Lasswell's model.

MoGC consists of Vehicle-Participatory Content (VPC) and Vehicle-Generated Content (VGC), which are simply defined in our prior work [41]. As shown in Figure 2, combined with ICV-aided MoGC, the content-generated patterns are used for different entities in various conditions. The relationship between MoGC and existing patterns can be categorized into two aspects: participant entity and generation workflow.

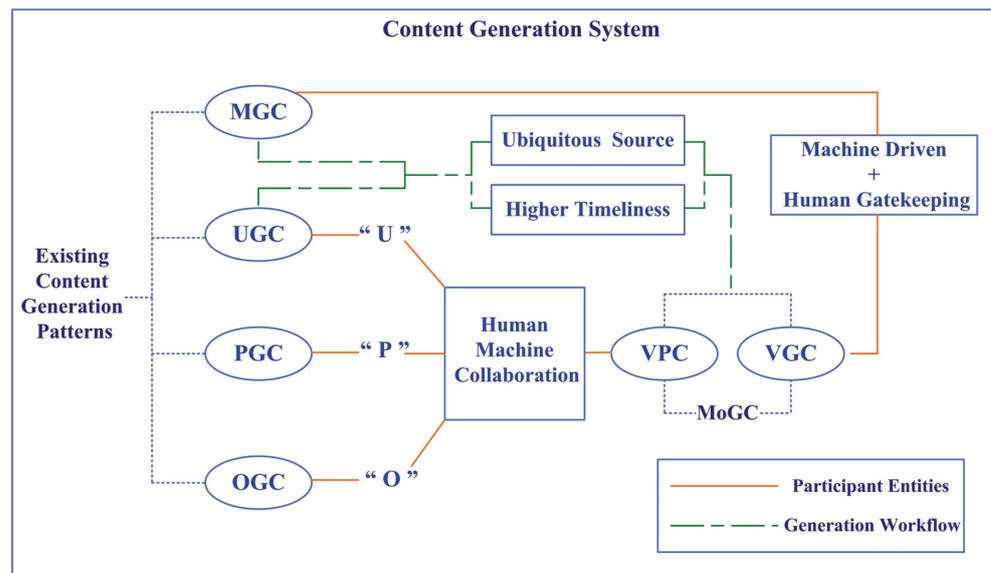


Figure 2. MoGC-empowered content generation system.

### 2.1. Participant Entities

Among all the production patterns, participant entities can be divided into four categories: the ordinary people in UGC, the internet celebrity aided by production/planning company in occupationally-generated content (OGC), the professional organization in PGC, and the auto-generation system or robot in MGC. Definitely, the MoGC pattern involves four kinds of entities and certainly is more complex than existing modes. Their common grounds can be summarized as follows:

#### 2.1.1. Human-Machine Collaboration

The inventive ideas or creativity play a vital role in making the fantastic content [42] to capture users' eyeballs [43]. Meanwhile, creators continuously improve the quality of content by various photographic or film-making techniques and the user experience can be enhanced through omnipresence productions, e.g., the immersive media in light of multiple views synthesis. It is worth noting that human-machine collaboration is always required in the process of creative design, information acquisition, processing and production.

In mobile scenarios, ICV as the giant media can assist ordinary users, professionals, and organizations to generate mobile content by using in-vehicle hardware and software resources in the moving process, namely as VPC pattern [41]. As an indispensable part of MoGC, the participant entity of VPC is the same as that of UGC, PGC patterns, i.e., the IVI user is no longer the consumer, but the active producer of media content by ICV. However, when the platform and news agency gather sufficient comments and content from producers, the decision-makers are required to select proper creations as quickly as possible. With the assistance of medium resource management system (e.g., BBC Hub for newsrooms [44,45]), the efficiency of gatekeeping has been improved to deal with the large amount of generated materials compared with traditional editors.

#### 2.1.2. Machine-Empowered Production

Apart from human beings, machines emerged as prolific content producers, e.g., robots. Unlike UGC, the MGC pattern depends on the sensor-based system/platform to generate the instant text and audio-video automatically, which is useful in difficult or extreme circumstances. As shown in Table 2, the legacy news institutions have already deployed MGC systems to realize the functions of intelligent editing and captioning, entity recognition, fake news detection in breaking news, sports, and finance, etc. Thereby, machine-oriented content has become popular, which differs from the human-oriented UGC and PGC [46–48].

As the supplement of the MGC pattern in vehicle-mounted scenarios, the VGC pattern relies on ICVs to produce machine-driven content directly in travelling and stationary [41]. Vehicular sensors automatically collect the surrounding information without intervention. In partnership with production platforms, the edited creations are sent to the distribution system and then the gatekeeper reviews that content to decide whether take measures or not before release, which is particularly meaningful for the materials of incidents and public security cases. In this way, ICVs not only bridge the services of radio and Internet applications, but also become an efficient production system. The large amount of ICVs with flexible routes is easy to deploy and use for MoGC among intra/inter-vehicular environments in sustainable cities. For the moving entities with fixed routes, e.g., subway and trains, it would be helpful to operate the tasks of natural hazards, overhead or underground line patrol, wildlife protection, etc. in a village or remote area.

**Table 2.** Machine-generated content (MGC) platforms.

Platform/Bot Name	Institutions	Features
QuakeBot [49]	Los Angeles Times	Receive earthquake notices and then generate drafts for newsroom
Salco [50]	BBC	Auto-generate local news by data processing, story generation and editorial approval by one-click
Lynx Insights [51]	Reuters	Generate data-driven story for sports and finance
Rosalinda [52]	MittMedia	Report the sport matches data and local news
Valtteri [53]	University of Helsinki	Generate the election result news in the languages of Finnish, Swedish and English
Pixello [54]	Broadcasters, Clubs, Leagues, Colleges etc.	AI-automated sports production, capture footage, clip highlights and show replays
MAGIC [55]	Xinhua News Agency	Produce short video automatically in few seconds

## 2.2. Production Workflow

In the production workflow of collecting, reporting, disseminating, and analyzing, fresh and timely sources are vital to guarantee the quality of news. MoGC and existing patterns make good use of ubiquitous sources alone with the journalists to create high time-sensitive materials for target audiences. In this way, the efficiency of content production can be greatly increased for both newsrooms and social media.

### 2.2.1. Ubiquitous Source

Among emerging production patterns, external sources (e.g., story, comment, feedback) provided by different participant entities could enrich news content and let the related institutions respond quickly to the change in our society. For example, the UGC pattern inspires the creative potential of ordinary people from all works of life to generate mass-oriented content by mobile devices, which lead to the prosperity of citizen journalism [56] in addition to legacy news team. Sometimes, the users who encounter the emergency with high news worthiness turn to the “first witness” and then play the partial role of mobile journalist [57] to record the first scene. The materials taken by different users from their perspectives could draw the whole pictures of the event that journalists may ignore in their interviews.

Vehicles become ever more connected and generate more data that can be utilized as news sources. Compared with MGC and UGC, MoGC has further expanded the range

of collection subjects and sources in transport and living spaces. Especially, thanks to the performance of IoV and high penetration rate, ICVs could replace smart phones with a dominant position in mobile media era to collect the omni-information. Moreover, it is also worth noting that MoGC offers rich media forms in text, audio, images and video, which are the same as UGC, PGC, and MGC. Supported by vehicle-equipped millimeter-wave/laser radar, front/rear/surround camera and ultrasonic sensor, it would help producers discover multiple perspectives and discover clues without limitations of time and space, which can be viewed as virtual journalists and gathering centers in cities and villages. According to the mobile nature of ICVs, the collaborate MoGC will minimize the information loss due to blind spots and contribute to the development of vehicular journalism.

### 2.2.2. High Timeliness

Timeliness is an important element of news, which puts forward higher requirement for the production system and content-generated patterns. UGC, MoGC and MGC patterns show the advantage of high timeliness because of the large amount of engagement. For UGC pattern, the advanced technologies transfer audiences to producers and empower users to tell their stories via social media and news agency [58,59]. Especially, if breaking news occurs, nearby users can immediately report the details on social accounts even before mainstream media. MGC utilizes the intelligent platform with highly aggregated resources and sufficient capability enable real-time collection, editing, distribution and feedback analysis, e.g., the “MAGIC” platform to create a short video within 6 s in the Russia World Cup [55]. For MoGC patterns, relying on the coordination, a large amount of ICVs can be dispatched or volunteer to the target position (like the rescue vehicles) as quickly as possible to obtain desired content. On the other hand, the MoGC’s workflow of collection, editing, production, and distribution is all done by the IoV-based production platform. There is no need to switch between various tools and media center, which can simplify the generation cycle and save the round-trip delay.

## 3. Properties of MoGC

As mentioned beforehand, MoGC is related with existing patterns in terms of both the involved participants and production process. However, MoGC has distinctive features and social effects because of the different entity in a vehicle-mounted media scenario.

### 3.1. Functionality Property: Mobile Middle Platform

The middle platform is original from financial industry, which provides IT and risk services between front and back offices. Similarly, it emerges among high-tech companies to support multi-task and the reciprocity of data and technology in a standardized way, e.g., Alibaba middle office [60]. In order to facilitate the functionality of MoGC, the vehicle-mounted middle platform becomes a crucial component of MoGC ecosystem, which is necessary to deploy between the front platform (e.g., infotainment system) in user-side and back platform (e.g., publisher) in legacy (or social) media side.

As illustrated in Figure 3, the mobile middle platform consists of data and technology offices, which intends to integrate and reuse vehicle multiple systems, data centers for production by virtual architectures rather than deploying more equipments in the narrow space of automobile. The data office manages the structured, semi-structured, and unstructured data collected from various vehicular sensors and IVI applications, such as user profile, real-time audio and video. The process of storage, cleaning and analysis are performed to gain the data insight and then provide the “raw material” for MoGC. Moreover, considering the importance of cyber security and privacy in mobile scenarios, data security module is an indispensable part of data office. The generated data usually consist of usage records and user preferences, which are vulnerable to leaking the habits of drivers and passengers. In this way, the firewall is needed to block the network attack and allow the authorized users to access the generated materials, respectively. In technology office, the concrete editing modules are deployed to realize the functionalities of scene

perception, object recognition, voice conversion, audio/video transcoding, and intelligent subtitling, etc. In this way, ICVs become the mobile studio and flexibly responds to the production demands of IVI users and institutions during vehicle running status, which can extend function and capability of existing infotainment system. However, the distraction to drivers seriously effects traffic safety. The scene awareness module can not only use for content production, but also monitor the behaviours of drivers via eye tracking and gesture detection. If distraction issue occurs, the series of control measures will be taken and the drivers are alerted simultaneously.

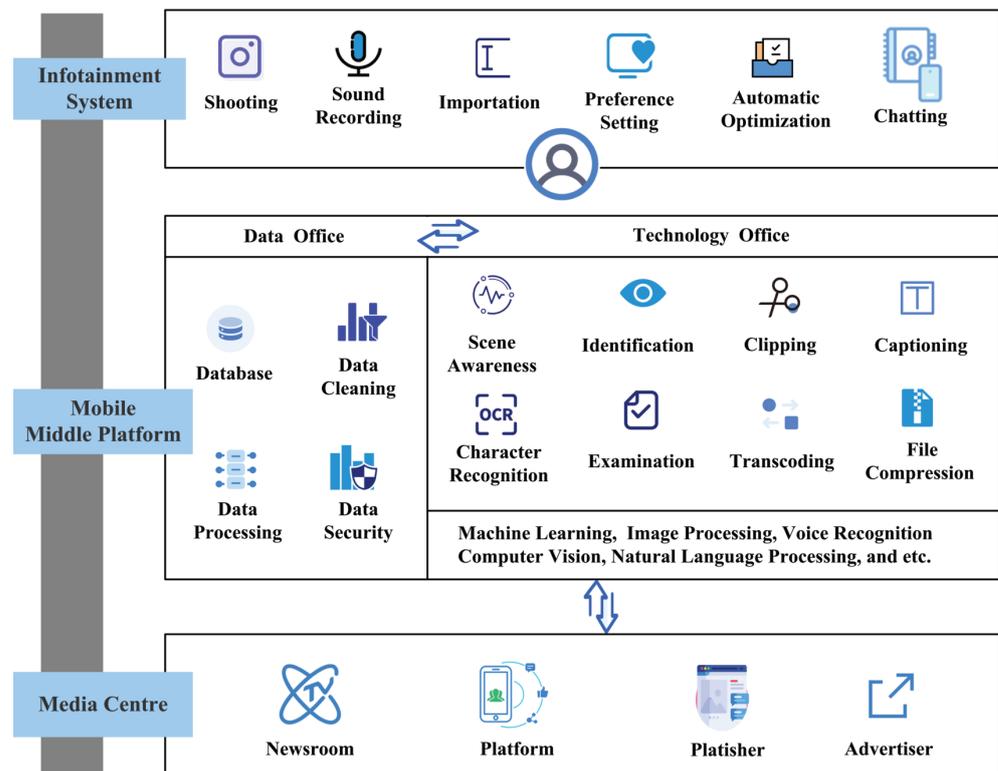


Figure 3. Mobile middle platform in MoGC.

### 3.2. Social Property: Discourse from Professional to Ordinary Users

Currently, professional institutions have a voice in the vehicle-mounted content generation. For example, legacy news agencies have already equipped with streamlined vehicles (e.g., OB vans [61]) for outdoor broadcasting. Besides, the governmental departments use refitted vehicles to perform some social governance tasks, e.g., monitoring public security, measuring velocity, and taking body temperature in COVID-19, etc. There is no denying that those activities can be regarded as the part of MoGC in-vehicle scenario. But, the participant entities still restrict to professional users or governmental institutions.

More general, the actual producers or participants of MoGC are both from public and professional organization. Especially, ICVs enable each IVI user to involve in making content by using vehicle-mounted equipments and resources during commuting. Therefore, the production rights is no longer belong to the mass media with specialized equipments and then will transfer to ordinary users. Depending on the mobile middle platform and the mobility property, each ICV becomes a content provider in a distributed way and then IVI users act as mobile journalists to output interactive media in vehicle-mounted scenarios. As a result, the civic engagement will be further enhanced in terms of social governance for public interests and news report. Meanwhile, the mainstream media face the stiff competition in outdoor live broadcast and its dominant position will be altered after MoGC being prevalent.

#### 4. Conclusions

In this paper, we have proposed the concept of Mobile-Generated Content (MoGC) aided by Internet of Vehicles (IoV), which can boost the production capacity of intelligent connected vehicles (ICVs) in smart cities. The relationships between MoGC and existing patterns have been revealed from the aspects of participant entities and production workflow, respectively. Depending on vehicle-mounted resources, mobile middle platform consisting of data and technology offices is necessary to support the functionality of MoGC in ICVs and acts as the intermediate between the user interfaces and platisher systems in a flexible way. By leveraging the ICVs and their users, the mobile content can grow much faster than legacy news agency. Due to the popular engagements, the discourse in vehicle-mounted scenarios will be dominated by ordinary people rather than media institutions. We believe that IoV based MoGC can provide new opportunities to change the landscape of mobile media, especially for production and distribution manners.

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#### Abbreviations

The following abbreviations are used in this manuscript:

ICV	Intelligent Connected Vehicle
IoV	Internet of Vehicles
IVI	In-Vehicle Infotainment
MGC	Machine-Generated Content
MoGC	Mobile-Generated Content
OGC	Occupationally-Generated Content
PGC	Professionally-Generated Content
UGC	User-Generated Content
VGC	Vehicle-Generated Content
VPC	Vehicle-Participant Content

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