A Survey on Cloud Services for Mobile Users: Augmenting Mobile Resources

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Abstract— The main objective of our survey is to explore the cloud services for mobile users to provide seamless services and user experience to mobile device users irrespective of their limited resource constraints. Resource constraints in the mobile device namely low processing, limited storage and low battery time restricts the drastic handling of mobile devices in almost all areas of domain like Personal shopping, Healthcare, Education, Social media etc. A solution for resource constraints in mobile devices is Cloud services by which mobile users can outsource their storage and processing. In this paper, the diverse ways of providing cloud services to Mobile users are analyzed. Our survey depicts three major ways of mobile cloud service provisions which includes Cloud services from mobile device manufactures like iCloud, MI cloud, Mobile Network Operator's cloud services and other cloud service providers through Internet.

Keywords— Cloud Service, Mobile users, Mobile Resources, Augmentation, Mobile cloud, iCloud, MNO.

I.INTRODUCTION

Nowadays users want to access information and exploit facilities at anytime and anywhere. Mobile devices are their best choice, which provides the desired services irrespective of their location and time. In every market studied mobile phone dispersion is higher than desktop ownership. In 2017, more than 90 percent of internet users will access online content through their mobile phones [1]. Percentage of Mobile phone user accessing Internet is depicted in figure 1. Mobile social media networks and apps are increasingly well-liked during everyday activities and social events [2]. The usage of mobile devices for shopping activities has also become increasingly well liked. Currently, mobile payments are used by about 20 percent of global Smartphone users, showing large potential in emerging markets.
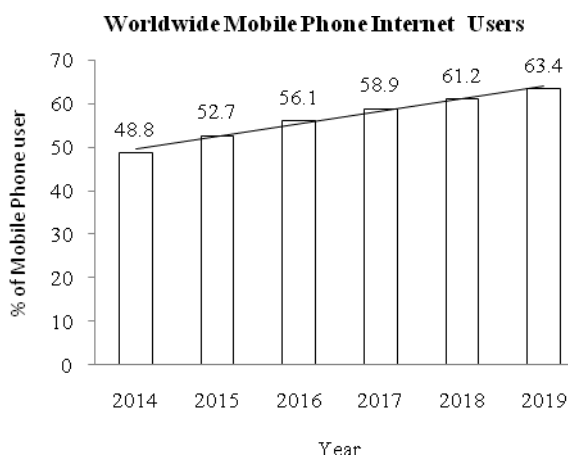

Figure 1: Internet access from Mobile phone

Google trends results for "Mobile App" from Jan 2015 to April 2016 are depicted in figure 2.
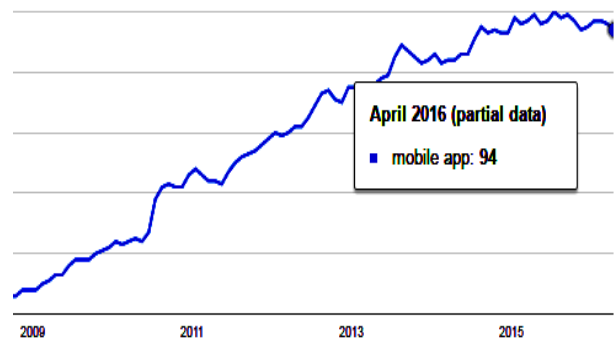

Figure 2: Google Trends for "Mobile App" from Jan 2009 to April 2016

Evidently, access to Internet from mobile devices is increasing rapidly. However, mobile devices cannot offer reliable services due to their restricted resource constraints such as limited battery time, low processing power and limited storage [3]. The drastic handling of mobile devices in almost all area of domains like Personal shopping, Healthcare, Education, Social media etc is restricted due to its resource constraints. Resource rich clouds can be exploiting to increase, enhance, & optimize computing and storage capabilities of mobile devices.

According to the official NIST definition, "cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction".

Cloud computing offers online data storage, infrastructure and application. Cloud Computing is highly cost effective because it operates at high efficiency with optimum utilization. Cloud services augment the resources of mobile device by which mobile users can outsource their storage and processing. Mobile cloud computing was defined in a 5 March 2010 entry in the Open Gardens blog as "the availability of cloud computing services in a mobile ecosystem. This incorporates many elements, including consumer, enterprise, femtocells, transcoding, end-to-end security, home gateways, and mobile broadband-enabled services." Cloud provides ubiquitous, on-demand, elastic, self-configurable, cost effective computing. Mobile devices are accessible, convenient gadgets, with regional wireless communication services and limited data services that have limited computing and power resources. [4]

II. MOTIVATION

Our survey is to analyze the cloud services for mobile users to provide seamless services and user experience to mobile device users irrespective of their limited resource constraints.

The following research findings emphasize the importance of our survey on cloud services for mobile devices.

From Gartner's top 10 strategy technology trends, the convergence of cloud and mobile computing will continue to promote the growth of centrally coordinated applications that can be delivered to any device. This analysis is essential and recognized as the first technological trend of 2015 by Gartner (Gartner Identifies the Top 10 Strategic Technology Trends for 2015). As mobile devices continue to proliferate, Gartner predicts an increased emphasis on serving the needs of the mobile user in diverse contexts and environments, as opposed to focusing on devices alone.

According to ABI Research, the limited processing and memory capabilities of mobile devices have always required some use of the "cloud" for delivery of mobile applications and services. However, the challenges inherent in Application development as well as the desire to enhance applications with location, presence, and other value-added services are driving greater use of the cloud for creating advanced mobile applications [5].

Mobile cloud computing is gaining stream. According to the latest study from Juniper Research, the number of mobile cloud computing subscribers is expected to grow rapidly in the next five years. Juniper Report highlights that the key to mobile's future depends on the processing power of the cloud itself. Cloud-based mobile apps can scale beyond the capabilities of any Smartphone. Cloud apps have the power of a server-based computing infrastructure accessible through an app's mobile interface [6].

The Mobile Cloud market includes a combination of cloud computing, mobile computing and wireless technologies and networks to enhance the computational power [6]. The beneficiaries of the technology are the mobile/Smartphone users, network operators and cloud service providers, since the Smartphone, tablet and cloud computing technologies are converging into the new mobile cloud market. The mobile cloud market is projected to grow from US$ 9.46 billion in 2015 to US$ 38.48 billion in 2020, at an estimated CAGR of 26.34%. It is estimated that by 2020, the market will have crossed the 1 trillion cloud-ready devices benchmark [7].

Figure 3: Mobile Data Traffic [Source: CISCO VNI Mobile Cloud]

Based on Cisco IBSG, Mobile cloud stands to significantly increase the overall value of mobility, as well as radically alter the way people live, learn, work, and play. Cisco Global Cloud Index forecasts by 2019, the majority of stored data (51 percent) will move to non-PC devices (e.g., Smartphone, tablets, M2M modules, et al.). With the volume of stored data increasing, Cisco predicts a greater demand and use for consumer cloud storage. By 2019, 55 percent of the residential Internet population will use personal cloud storage (up from 42 percent in 2014).

III. CLOUD SERVICE PROVIDERS FOR MOBILE DEVICE

We deliberated the diverse ways to augment the mobile resource constraints. Our survey depicts three major ways of mobile cloud service provisions which includes Cloud services from mobile device manufactures like iCloud, MI cloud, Mobile Network Operator's cloud services and other Internet cloud service providers.
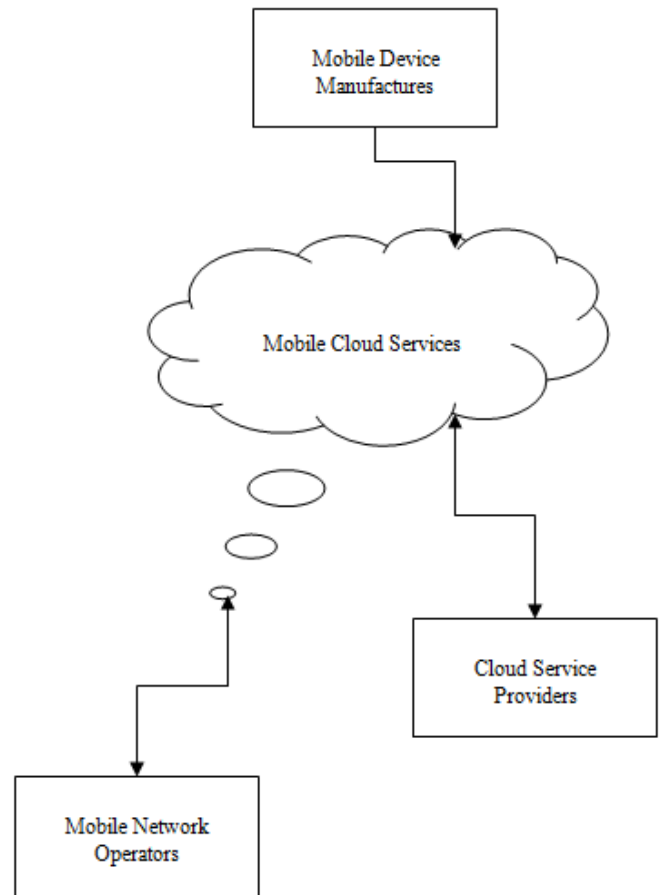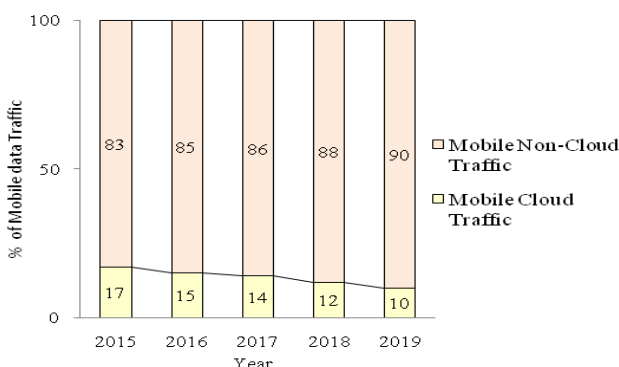

Figure 4: Cloud Service Providers for Mobile Services

A. *Cloud Services From Mobile Device Manufactures*

Mobile device manufactures are providing cloud services to magnetize their customers. For example iCloud from Apple, MI cloud from Redmi.

- iCloud connects all Apple devices namely iPhone, iPad, iPod or Mac and allows to share information like documents, photos, notes and contacts. It even helps the user to find their lost device. Also provides web-only access of 1 GB free storage for non iOS device users [8].
- Mi cloud grants 10 GB of free storage space to stash customer contacts, photos, videos and documents in the cloud [9].

Nevertheless the key shortcoming of these cloud services is device dependent services. Moreover, every one of the mobile device manufactures is not affording these cloud services.

B. *Cloud Services From Mobile Network Operators*

For our analysis, we considered the following five Mobile Network Operators in India.
1) Bharti Airtel

2) Vodafone
3) Idea
4) Aircel
5) BSNL

Bharti Airtel Cloud Services

Airtel [10] provides state-of-the-art Tier 3/3 + Data Centers to host business critical IT & Telecom equipments and applications. Data Center services include entire suite of managed hosting, storage, business continuity, data protection and security services. Airtel launches cloud computing service on broadband. IaaS of Airtel cloud enables hosting of all applications for deployment.

Vodafone Cloud Services

Vodafone's [11] secure and flexible Cloud and Hosting Services offer centralized and scalable IT solutions across a mixture of platforms. Global co-location services provide the highest quality, secure data centre resources for a predictable monthly rental. Vodafone Flexible Computing for Government is an 'on-demand' flexible and scalable multi-tenant public cloud service, but with the added security and assurance of a platform approved to hold Protectively Marked Information at 'Restricted' status. Available under the G-Cloud and PSN procurement frameworks, user can consume the service in line with the Government's mandated 'Cloud First' policy.
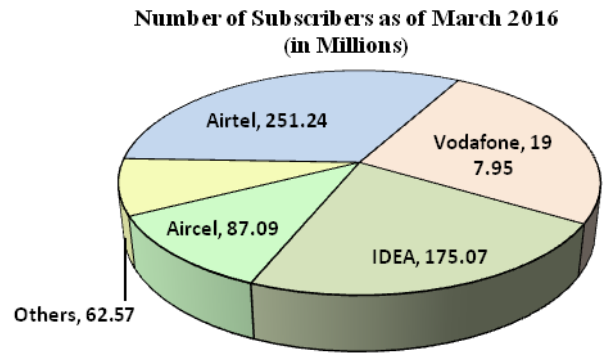
Vodafone's Primary Storage aids the user to choose from multi- or single-tenant platform and four service tiers, based on price and performance. It also offers a fusion approach, with dedicated primary storage alongside multi-tenant backup and restores platforms. Data Protection provides industry-leading backup and disaster recovery technology to protect the critical business data. Protection services include encryption, de-duplication and off-site tape storage.

Idea Cellular Cloud Services

Idea [12] offers cloud based architecture, thereby reducing any CAPEX investments. Idea E303 is a cloud based dongle wherein apart from superior speeds subscriber also get 2GB of cloud space for uploading and sharing files, images etc apart from access to Cloud messenger and cloud gallery. Idea Field Automation (FFA) is a mobile CRM Tool that helps to speed up and streamline all phases of business from prospecting, lead management, sales tracking, stock, services and order management.

Aircel Cloud Services

ABS [13] offers a state-of-art, ISO 27001 certified, carrier-neutral Green Data Center, strategically located in the IT Hub of North India, Gurgaon to service business continuity and connectivity requirements. Aircel Data Center offers Collocation Services, On-Demand Remote Hands & Eye Support and Carrier Neutral Connectivity Options. With Aircel Cloud Backup service, enterprises will be able to set global policies, schedules backups, retrieve the backed up data when required and manage the entire data lifecycle management from a single interface. The service also includes block level backup, strong management console, device agnostic backup, mapped drive backups and operating system backup. Budget-talk-VoIP services offers Pay-per-use IP calling solutions at competitive rates. Aircel also provides Music Cloud to listen, watch and download videos at anytime and anywhere.

BSNL Cloud Services

BSNL cloud [14] is the India's first and the world's largest Tier-III data centre cluster certified by Uptime Institute. It has six data centres in India which offers world-class services like Managed Hosting, Rack space and custom built cage space in Managed Colocation, a host of IaaS, PaaS and Saas based Cloud Computing Services . These fully-secured data centres in India, built to TIA 942 standards, are spread across India in six strategic cities and 63,500 square feet.Data centres in India are connected via provider backbone-based interconnectivity, with point-to-point Ethernet tunnels to deliver additional bandwidth, support provisioned QoS metrics and <50ms switchover to a provisioned protection path. It can act as a single virtual instance to reduce latency and provide higher bandwidth.

Source: Cellular Association of India

Figure 5: Number of Mobile Phone Subscribers

As per Telecom Regulatory Authority of India (TRAI), the overall telecom subscriber base has augmented every year. The overall subscriber base in Millions is depicted in Table-1[source: TRAI] and also shown in Figure 6.

Table 1 Number of wireless and wireline subscribers

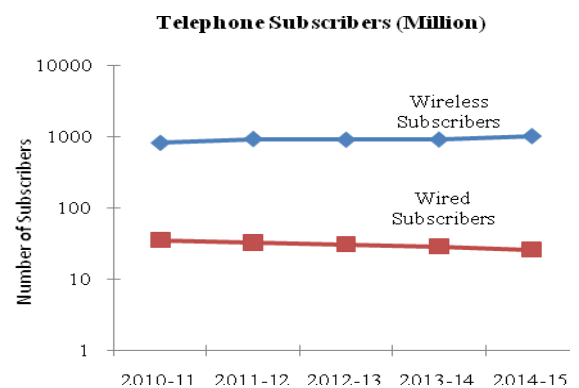| Year	Wireless Subscribers (Millions)	Wireline Subscribers (Millions)	Total Subscribers (Millions)
2010-11	811.59	34.73	846.32
2011-12	919.17	32.17	951.34
2012-13	898.02	30.21	898.02
2013-14	904.51	28.49	933.00
2014-15	1009.46	25.72	1035.18

Figure 6: Number of Telephone Subscribers

Among the above telecom subscriber, the number of Internet Subscribers for last three years is depicted in Table-2 and also shown in figure7.

Table 2 Number of Internet subscribers

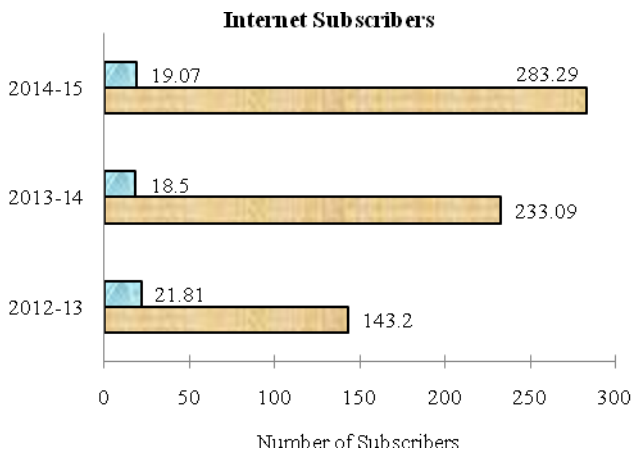| Year	Wireless Internet Subscribers (Millions)	Wireline Internet Subscribers (Millions)
2012-13	143.20	21.81
2013-14	233.09	18.50
2014-15	283.29	19.07

Figure 7: Number of Internet Subscribers

The aforementioned table and chart clearly states that the number of Internet subscribers through wireless device drastically greater than its wired counterpart and also increases significantly for every year. As per the performance indicator report from TRAI, Fixed Wireless Internet subscriber's growth rate is extensively smaller than that of Mobile Wireless Internet access.

Table 3 Number of Fixed & Mobile Wireless subscribers

Year	Fixed Wireless (Wi-Fi, Wi-Max, Point-to-Point Radio & VSAT)	Mobile Wireless (Mobile & Dongle)
2012 - 2013	0.46	219.92
2013 - 2014	0.46	248.06
2014 - 2015	0.49	304.85

The following chart depicts the composition of Internet Subscribers by mode of access.
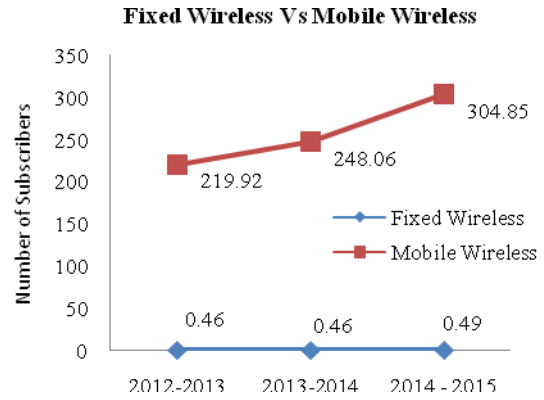

Figure 8: Number of fixed and mobile wireless Subscribers

Aforementioned tables and charts clearly state that Internet access by wireless mobile subscriber is set to grow many times in the forthcoming years.

Resources and Infrastructures of Mobile Network Operators can be leveraged as cloud services for larger mobile community [15]. These MNO-cloud services will propose further business opportunity for MNOs. Several telecoms already acquire large and distributed data centers but accessing this service is expensive and slower when compared to cloud services. However Telecoms provide customer relationship, billing expertise and customer services which are essential for the deployment of cloud services [16].

Moreover MNO can grant and augment privacy and security of the mobile cloud services. In future, the role of MNO in cloud service will be better and faster for customers and also for enterprises.

C. Mobile Services From Internet Cloud Service Providers

Various service providers are offering cloud services; we examined four cloud service providers.

Table 4 Comparison of Cloud Service Providers services

Cloud Service Provider	Google Drive	Dropbox	OneDrive	Amazon Cloud Drive
Location of Cloud Server	California, US	California, US	Washington, US	Virginia, US
Mobile Operating System	iOS /Android	iOS /Android	iOS /Android	iOS /Android
Free storage	15GB	2GB	15GB	0GB
File Size Limit	50MB, file size limit based on type of file	No File Size Limit	10GB	2GB
Portable app execution	Yes	Yes	Yes	Yes

Multiple parallel downloads	Yes	Yes	Yes	Yes
Ability to choose local folder	Yes	Yes	Yes	No
Sharing URL / Folder	Yes	Yes	Yes	Yes
Limit Share Time	Yes	Yes	No	No
Password protection of shared URL	Yes	Yes	No	No
End-to-end encryption	No	No	No	No

Mobile Cloud services are leveraged by individual and Enterprises. We deliberated the following Cloud Service providers.

- Amazon
- Microsoft Azure
- IBM
- Google
- Oracle

- *Amazon Mobile Cloud Service*

Amazon Web Services (AWS) [17] is a secure cloud services platform, offering compute power, database storage, content delivery and other functionality to help businesses scale and grow. AWS Cloud provides a broad set of infrastructure services, such as computing power, storage options, networking and databases, delivered as a utility: on-demand, available in seconds, with pay-as-you-go pricing.

Amazon Web Service Mobile Hub [17] offers easily add and configure features for mobile apps, including user authentication, data storage, backend logic, push notifications, content delivery, and analytics. After building app, AWS Mobile Hub gives easy access to testing on real devices, as well as analytics dashboards to track usage of mobile app – all from a single, integrated console. AWS provides API to create a mobile backend without provisioning or managing servers. Just uploading code and run it by calling directly from mobile application by AWS Lambda will take care of everything required to run and scale code.

- *Microsoft Mobile Cloud Service*

Microsoft Azure App Service [18] is a new and unique cloud service that enables developers to create web and mobile apps for any platform and any device. App Service is an integrated solution designed to streamline repeated coding functions, integrate with enterprise and SaaS systems, and automate business processes while meeting the needs for security, reliability, and scalability. App Service brings together the existing Azure services - Websites, Mobile Services and Biztalk Services into a single combined service, while adding powerful new capabilities. App Service allows to host the app types like Web Apps, Mobile Apps, API Apps and Logic Apps.

- *IBM Mobile Cloud Service*

IBM Mobile Cloud Service [19] is used to design and build mobile apps faster and simpler. Also enhances mobile app performance and deliver a great user experience with a multi-platform cloud infrastructure. IBM API Management helps to design, secure, and socialize APIs that integrate mobile applications with enterprise systems and third-party cloud services. IBM Mobility Services reduce the risk and complexity of managing mobile technologies across the enterprise.

- *Google Mobile Cloud Service*

Google Cloud Endpoints [20] consists of tools, libraries and capabilities to generate APIs and client libraries from an App Engine application, referred to as an *API backend*, to simplify client access to data from other applications. Endpoint makes it easier to create a web backend for web clients and mobile clients such as Android or Apple's iOS. For mobile developers, Endpoints provides a simple way to develop a shared web backend and by using App Engine for the backend, developers are freed from system admin work, load balancing, scaling, and server maintenance. It is possible to create mobile clients for App Engine backend without Endpoints. However, using Endpoints makes this process easier because it frees to write wrappers to handle communication with App Engine.

- *Oracle Mobile Cloud Service*

Oracle Mobile Cloud Service [21] provides tools to develop a strategy for supporting mobile development. User can get the out-of-the-box services that every mobile app requires, plus the ability to define and implement new enterprise-ready APIs quickly and cleanly. Moreover, all API calls from Android, iOS, Windows/C#, or JavaScript client applications are made via uniform REST calls, thus creating a cohesive development environment that's easy to control and maintain.

IV. MOBILE CLOUD SERVICES

Mobile access is one of a key selling point of cloud computing services in their wide-ranging access. Cloud services allow the user to access their content anywhere, anytime and on any one of their devices. Cloud services for mobile devices offer the greatest range of mobile access, including apps for popular Smartphone and the ability to log into user account from any mobile browser.

Advantages of Mobile Cloud Services

- **Augmenting resources of mobile device:** Mobile cloud services augment the resources of mobile device by outsourcing storage and processing of mobile devices.
- **Accessing Data:** User can access data which is stored in cloud by any mobile device, at anytime and anywhere.
- **Platform Neutral:** Cloud data supports mobile platform independent access; data stored in cloud can be accessed by any mobile platform like iOS, Android, Blackberry.
- **Data Sharing: I**t is easy to share the cloud data like images, audio, video among mobile devices and persons.
- **Additional Backup:** By storing the data of mobile device in cloud, cloud acts as a backup server during recovery events like mobile theft, loss and crash.

Disadvantages of Mobile Cloud Services

- **Internet Connectivity:** Cloud services for mobile devices require reliable Internet connection.

- **Privacy and Security:** Sensitive information provided by mobile user must be protected efficiently and also permits its access to authenticated users only.
- **Performance:** Performance of mobile cloud app is not as good as with native applications in many cases. Therefore checking with cloud service provider and understanding their track record is worthwhile [16].

CONCLUSION AND FUTURE ENHANCEMENTS

Our survey reveals that growth of Wireless Internet access by Mobile device is increasing drastically when compared with wired Internet access. However the usage of mobile device is restricted by its limited resources. Cloud Services can augment the resource constraints of Mobile devices thereby providing secured, reliable services to mobile users. Our examination depicts three major ways of mobile cloud service provisions which includes Cloud services from mobile device manufactures like iCloud, MI cloud, Mobile Network Operator's cloud services and other cloud service providers through Internet.

Our future work is augmenting Mobile resource by MNO's Cloud service as fog computing. Since, MNO's are already trustworthy service providers for mobile users. Moreover existing mobile billing can be easily extended for mobile cloud service.

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