

Cloud Computing
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Lecture - 31
Mobile Cloud Computing – I

Hello. We will continue our discussion on Cloud Computing. Today we will look at one aspect of or on one application of this cloud computing or would you say that amalgamation with other technology, what we look at in a mobile cloud computing. Though mobile cloud computing itself has now become a topic or subject as a whole, but we will try to look at the different aspects of mobile cloud computing basically overview of the things, that where what are the different features characteristics where is the need and so on and so forth.

So, as we see in today's world, these mobile devices or what we say Smartphone devices or smart mobile devices are have a huge purification in our society right from different category of people to different level of application and so on and so forth. So, that has created a revolution in the communication path. So, there are a couple of things one is that this huge purification has is possible or because of easy availability or low cost high bandwidth availability at the back end. So, there are service provider or back end service providers which provides networking to these devices.

Secondly, we also have a scenario that with very resourceful. So, to say quote unquote resourceful in the devices are coming up, which are much resourceful than yesterdays devices right. So, there is a upliftment of the resources till that is not matching with the type of things which we have on the desktop or other type of servers, but nevertheless it is a resourceful device, it is a smart device it has in capability of not of sensing and running lot of apps and you have a backbone networking which allows you to communicate in a bigger way. So, all those things has given up a trend that whether I can use these device for computing purpose right.

So, or if I have some applications which is running, which requires some good amount of computing where there is a provision of uploading this sort of computing activity to some other more resourceful equipment or something. So, here they came as a natural need of that interfacing between the cloud and mobile devices right. So, that mobile

devices it can offload it is some of these computing phases or computing modules to the other to the cloud and get it back and go on running, that could have been marvellous thing right. Like I can say that I am sensing some information environmental things then I want to do a predictive model that what is going to be there very. So, very short term prediction and then that predictive model requires.

So, much more resources than sensing and doing in some initial analysis. So, I what I do that this thing is offloaded to a much higher resourceful infrastructure say cloud, and I get the results and analyze the result at my end or with other collateral data. So, there can be lot of type of applications which involves some sort of a data analysis data analytics which could have been offloaded other things. So, this sort of amalgamation whether it is possible, what sort of architecture is there what are the different type of challenges that we would like to look at in this lecture maybe one or two cop consecutive lectures.

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Motivation

- Growth in the use of Smart phones, apps
- Increased capabilities of mobile devices
- Access of internet using Mobile devices than PCs!

- Resource challenges (battery life, storage, bandwidth etc.) in mobile devices??
- Cloud computing offers advantages to users by allowing them to use infrastructure, platforms and software by cloud providers at low cost and elastically in an on-demand fashion

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So, today we will talk about basics of mobile cloud computing what are the things. So, what we see what motivates as we are discussing, there is a huge growth of Smartphones or uses of the Smartphone and not only the phone of smart applications right. Increased capability of the mobile devices in terms of running these applications and resources, access of internet mobile devices became pretty easy like this connectivity of these mobile devices with a back end internetworking; resource and on the other hand there are some of the things resource challenges like battery life storage bandwidth these are some

of the resources challenges, if there is if the application is heavy that is more require more resource to execute this or what we say resource hungry applications right.

So, in mobile devices cloud computing on the other hand offers the advantage to the users by allowing them to use infrastructure platforms software by cloud providers as a low cost and elastically in an on demand fashion as we have seen that the cloud computing on the other hand provides the user with a low cost elastic service like. As pay as you go model and whether there is a possibility of amalgamation exactly what we are looking trying to say we need to talk about mobile cloud computing or sometimes abbreviated at MCC right. So, to have something mobile and something at your finger tips while you are move.

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MobileBackend-as-a-service

What	<ul style="list-style-type: none">Provides mobile application developers a way to connect their application to backend cloud storage and processing
Why	<ul style="list-style-type: none">Abstract away complexities of launching and managing own infrastructureFocus more on front-end development instead of backend functions
When	<ul style="list-style-type: none">Multiple Apps, Multiple Backends, Multiple DevelopersMultiple Mobile Platforms, Multiple Integration, Multiple 3rd Party Systems & Tools
How	<ul style="list-style-type: none">Meaningful resources for app development acceleration – 3rd party API, Device SDK's, Enterprise Connectors, Social integration, Cloud storage

<http://www.rapidvaluesolutions.com/whitepapers/How-MBaaS-is-Shaping-up-Enterprise-Mobility-Space.html>

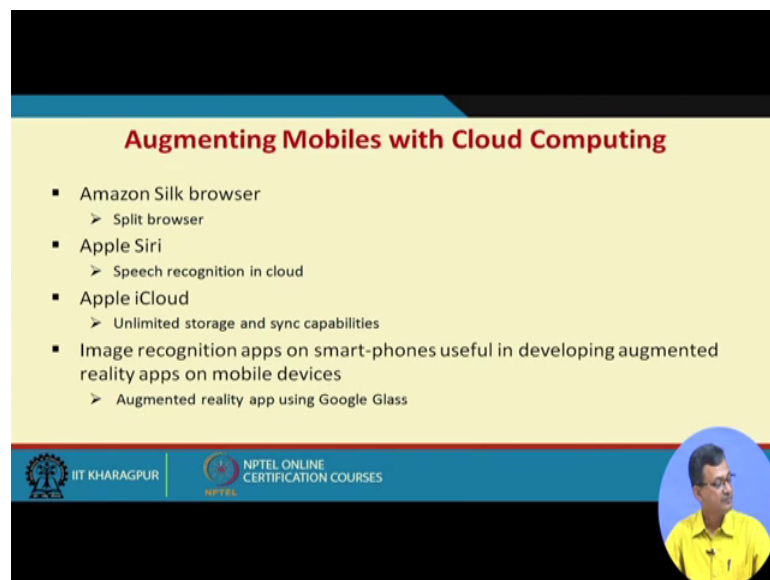
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So, something what we trying that mobile backend as a service type of things like as we try to do everything xa is type of things x, x anything as a service. So, why not mobile backend as a service like, what we when you look at it? It provides mobile application developers a way to connect to their applications back in cloud provider and cloud storage and processing. Abstract away complexity of launching managing own infrastructure right that is a need. Focus more on the front end development instead of the back end functionalities right.

So, that it is more on the how this apps will be develop rather looking at that how my back end how to manage the back end and so on and so forth. So, multiple apps multiple

back end, multiple developers things are possible multiple mobile platforms multiple integration multiple third party systems and type of things. That means, there is a integration or multi party type of systems and meaningful resource for app development like third party API devices decays enterprise connected and so and so forth.


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Augmenting Mobiles with Cloud Computing

- Amazon Silk browser
 - Split browser
- Apple Siri
 - Speech recognition in cloud
- Apple iCloud
 - Unlimited storage and sync capabilities
- Image recognition apps on smart-phones useful in developing augmented reality apps on mobile devices
 - Augmented reality app using Google Glass

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So, there are different what why when how type of things, which are which there is a possibility of answering this type of situations. Now augmenting these mobiles with cloud computing there are several efforts or initiatives like amazon silk browser, which is a split browser Apple siri, apple iCloud, image recognition apps on Smartphones useful in developing augmented reality apps in the mobile devices. So, all those things at the back end it talk to a cloud right. So, it may be for storage, it may be for computing, it talk to a cloud. The things are possible primarily because you have a intermediate high bandwidth scenario right, that you seamlessly things that as if the calculation is working on the mobile device.

So, that this type of delay can be metalized can be handled right. So, whenever I offload any application or any computing things to some other things a couple of things come into play right. One is that there should be a fill of that the as if the application running on the device itself so; that means, intermediate delays in offloading. So, this particular portion of the application the whole application should be minimum right. There are other things like if I want to do a dynamic offloading, then I need to do lot of things like

I need to appropriately partition the things, need to have a lot of synchronization in to play and if there are dependencies with other applications those has to be taken care.

So, this is not a straightforward scenario there are lot of lot of complexity involved in unit, and lot of timing relationships and other things come into play right.

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What is Mobile Cloud Computing?

Mobile cloud computing (MCC) is the combination of cloud computing, mobile computing and wireless networks to bring rich computational resources to mobile users.

- **MCC provides mobile users with data storage and processing services in clouds**
 - ✓ Obviating the need to have a powerful device configuration (e.g. CPU speed, memory capacity etc.)
 - ✓ All resource-intensive computing can be performed in the cloud
- **Moving computing power and data storage away from the mobile devices**
 - ✓ Powerful and centralized computing platforms located in clouds
 - ✓ Accessed over the wireless connection based on a thin native client

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So, if it can be managed then we can have scenario things like computing. So, if you would try to look at what mobile computing is as a definitions, there are lot a there are a number of definitions available across the internet few we are trying to look at.

So, it is a combination of cloud computing mobile computing and wireless network, intermediate wireless networks to bring rich computational resources to the mobile users. So, that is one of the aspects of the thing. So, MCC provides mobile user with data storage and processing services on cloud. So, it is provide mobile users with data storage and processing service that primarily the two things. So, other thing is that moving computing power and data storage away from the mobile device. So, in some case in other cases what we do that the I detach this computing power or migrate this computing power and the storage to this cloud infrastructure.

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What is Mobile Cloud Computing?

Mobile cloud computing (MCC) is the combination of cloud computing, mobile computing and wireless networks to bring rich computational resources to mobile users.

- **MCC provides mobile users with data storage and processing services in clouds**
 - ✓ Obviating the need to have a powerful device configuration (e.g. CPU speed, memory)
 - ✓ Allowing users to access services from anywhere, anytime
- **Moving applications and data to the cloud**
 - ✓ Providing a consistent user experience across devices
 - ✓ Accessed over the wireless connection based on a thin native client

Mobile Cloud computing is the combination of cloud computing and mobile networks to bring benefits for mobile users, network operators, as well as cloud providers

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So, this two primarily things are there and we can say it is a combination of cloud computing, mobile networks to bring benefits of the mobile users network operators as well as the cloud providers. So, it is a some sort of a what we quote unquote win situation to a have all those things.

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Why Mobile Cloud Computing?

Speed and flexibility
Mobile cloud applications can be built or revised quickly using cloud services. They can be delivered to many different devices with different operating systems

Shared resources
Mobile apps that run on the cloud are not constrained by a device's storage and processing resources. Data-intensive processes can run in the cloud. User engagement can continue seamlessly from one device to another.

Integrated data
Mobile cloud computing enables users to quickly and securely collect and integrate data from various sources, regardless of where it resides.

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So, why computing mobile computing or MCC; this is well understood first of all what we look at the speed and flexibility, mobile applications can be build on or revised

quickly using the cloud services. So, two things are there, that I can have a lot of speed up on the things right.

So, computing as cloud are more resourceful things it can be do immediately there is another thing is that if there is a apparatus and needs and something has to be there like suppose I am using a algo for finding a minimum path or minimum distance between point a and point b on a typical map, then I can if there is a new heuristics come up I change at the clouded and it is seamless for my front end application at the mobile device, whether to how to offload on the cloud. It is only the duty to offload the things the rest is calculation is there right.

So, based on that different situations or different scenarios, I can have different algos and things coming up. So, then it is something a detachment detaching that actual processing from the devices. So, it is both flexible and speedy thing shared resources I can use shared resources mobile apps that can run on cloud are not constrained by device storage and processing resources data intensive processes can run on the cloud, user engagement and continuing seamless processes can round on the devices right. So, what do we say that some of the things can need to be done on the mobile devices some can be offloaded, that type of dynamic deals and partitioning is still a major challenge, right.

An integrated data, mobile cloud computing enables users to quickly and securely collect and integrate data from various sources regardless of their where it resides right like I want to do some sort of a disasters management type of things. So, if there is a disaster management system. So, on very quickly lot of data need to be collected by different sensors, which are mobile base and need to be run to see that what sort of other what sort of mitigation techniques to be there. So, there can be lot of applications which run at the back end which is in the cloud and can be integrated seamlessly along with the different sort of heterogeneous data sets.

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Key-features of Mobile Cloud Computing

Mobile cloud computing delivers applications to mobile devices quickly and securely, with capabilities beyond those of local resources

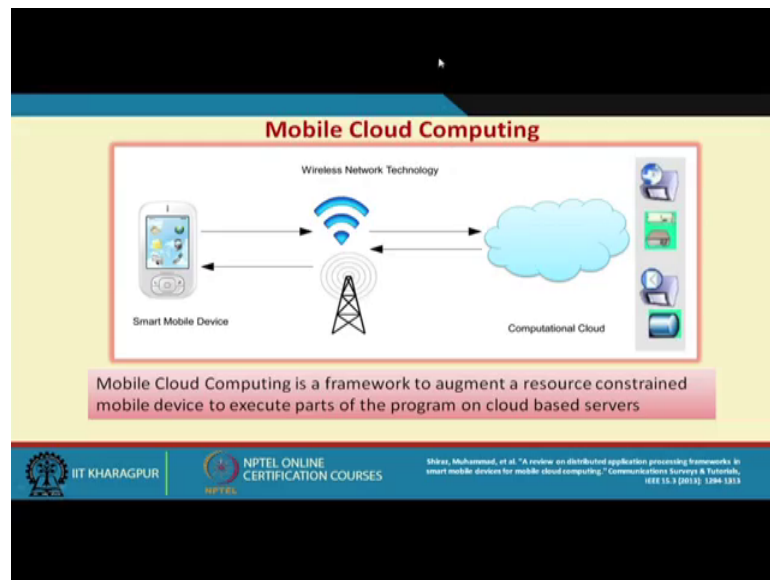
- Facilitates the quick development, delivery and management of mobile apps
- Uses fewer device resources because applications are cloud-supported
- Supports a variety of development approaches and devices
- Mobile devices connect to services delivered through an API architecture
- Improves reliability with information backed up and stored in the cloud

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So, if we look at the key features, the cloud computing delivers application to mobile devices quickly and securely and capabilities beyond those of local resources, like facilitates quick development delivery and management of mobile apps, uses fewer device resources because the applications are cloud supported. So, I have less the device resources or I am less loading the device resources, it is less battery power less heating up and you can run a lot of other apps into the thing right. Supports a variety of development and approaches where a development approaches and devices mobile is as it is doing at the at the cloud end.

So, that it can a same type of computing thing can support number of apps so; that means, easy to standardize across the things or running the reusability of some applications or reusability of algorithms is much higher. Mobile devices connect to services delivered through an API architecture improves reliability and information backed up and stored on the cloud right. So, it is not device dependent suppose you store the data at the device if the device goes down then the whole thing goes down, but is if I have a ah storage in the somewhere in the cloud with the other reliability into the place, like reliable storage facilities then my it is the my information is more reliably stores and can be handled.

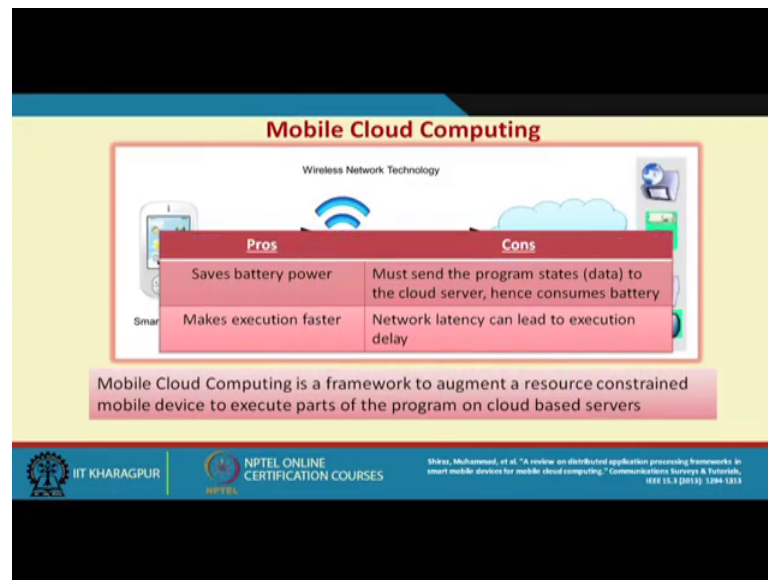
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So, if we look at. So, one end is this mobile devices or smart mobile devices sometimes we abbreviate as SMD other end is a computational cloud, and in between we have a wireless network technology provided by the service provider right. So, mobile cloud computing is a framework to augment resource says resource constrained mobile devices, to execute parts of the program on the cloud based servers right.

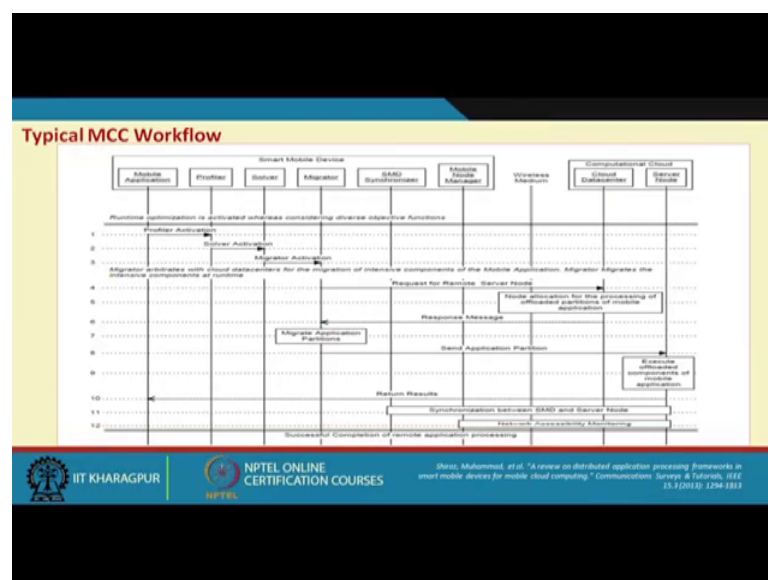
So, that is there no one can argue that these days mobile devices are much resourceful, but there is no match with the type of resources like cloud or a cloud-based servers can provide right. So, there is absolutely no match on the things so; that means, you can run now more powerful or more resource hungry applications into the device.

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So, there are pros like saves battery power as you are using less computing, makes execution faster at times if you have a good bandwidth and type of things. There are definitely the flip side of it must send the program state did or the state or state and data and the cloud server hence consume battery right. So, it is additional loading of transferring data network latency can lead with excuse and delay.

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So, if there are later on latency. So, there can be execution delay into the system. So, this is a overall big picture a flowchart. So, if you see that is one part is related to the mobile

devices, other part is more on the cloud computing things and how this workflow will go on. So, there are mobile apps. So, that should be a profiler which profiles this different that particular app and devices there is a solver of which takes care of that how this if I partition these and how it need to be profiled to be sent to the things, then how to solving will be there that is a SMD synchronization SMD stand for smart mobile devices, device and synchronizer that because if we do partition and execute in the on the cloud.

Then we need to take care of the how this synchronization process will go on and there is more while load manager right as to takes care that it says that data to the cloud captures the data, and how things are managed on the cloud and we have that cloud data sender and server nodes which are already we have seen we have discussed a lot on those things that.

So, it for the cloud it is a some sort of a third-party application or what we say there some third party a user requests coming to the things need to be executed within a particular queues within ah queues, and served with some SLA's. And need to be served right and in between we have a wireless media which plays a important role though it is neither computing or giving directly doing anything with the app, but it plays a important role in the sense that it takes care of this latency right or you need to take care of this latency.

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Dynamic Runtime Offloading

Dynamic runtime offloading involves the issues of

- dynamic application profiling and solver on SMD
- runtime application partitioning
- migration of intensive components
- continuous synchronization for the entire duration of runtime execution platform.

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So, if we look at the runtime offloading there are different tricky issues right or factors like a dynamic runtime offloading involves the issues of dynamic application profiling and solver on SMD right runtime application partitioning you need to partition the it is runtime migration of intensive come component like which are computational intensive component need to be migrated.

Continuous synchronization of the entire duration of the runtime execution platform, the long it is running we need to synchronize the things. So, if you look at these are very very tricky issues right, these are these are not any straight forward things anything doing dynamically runtime is extremely challenging right and. So, dynamic application profiling and solver in the SMD on that the mobile device runtime application partitioning, you need to partition on the runtime, migration of intensive components and continuous synchronization of the inter duration of the runtime execution platform.

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The slide is titled "MCC key components" in red text. It lists three components with their functions:

- **Profiler**
 - Profiler monitors application execution to collect data about the time to execute, power consumption, network traffic
- **Solver**
 - Solver has the task of selecting which parts of an app runs on mobile and cloud
- **Synchronizer**
 - Task of synchronizer modules is to collect results of split execution and combine, and make the execution details transparent to the user

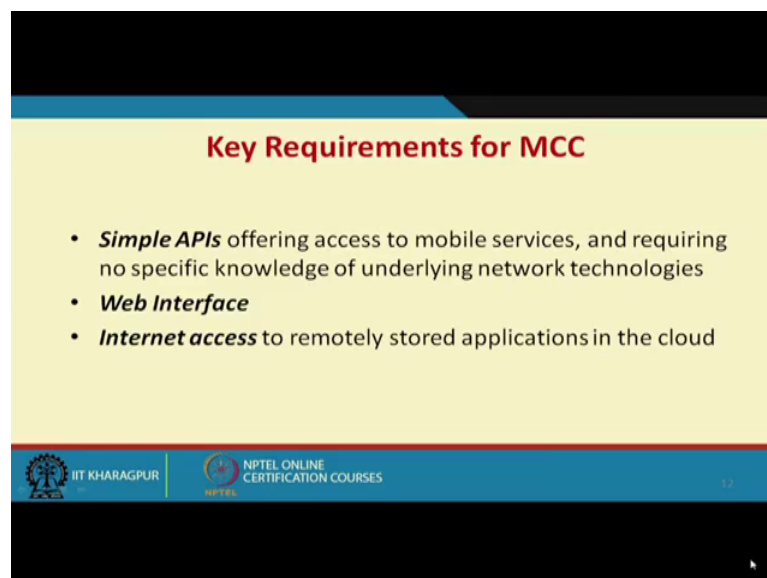
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So, this this these are there are major issues we need to be addressed or which are being addressed when you develop this type of mobile computing cloud computing apps there are several components some of the key components one is this profiler. So, which monitors a application execution to collect data about the time to execute power consumption and network traffic. Solver has the task of selecting which part of an app runs on mobile and cloud. So, it need to looked at that which you need to be use running

at the mobile end and we you need to be uploaded at the cloud end at the one of the main duty of the solver.

Synchronize at tasks of synchronizing module synchronizer module is to collect results of split execution and combine and make the execution details transparent to the user. So, that is important right you have partitioned the things runtime and this split execution things need to be again stitched together and give a user a some feeling that as if it is application run was running seamlessly on the device and without any much delay and type of things. So, this is also a very major challenge in handling this.

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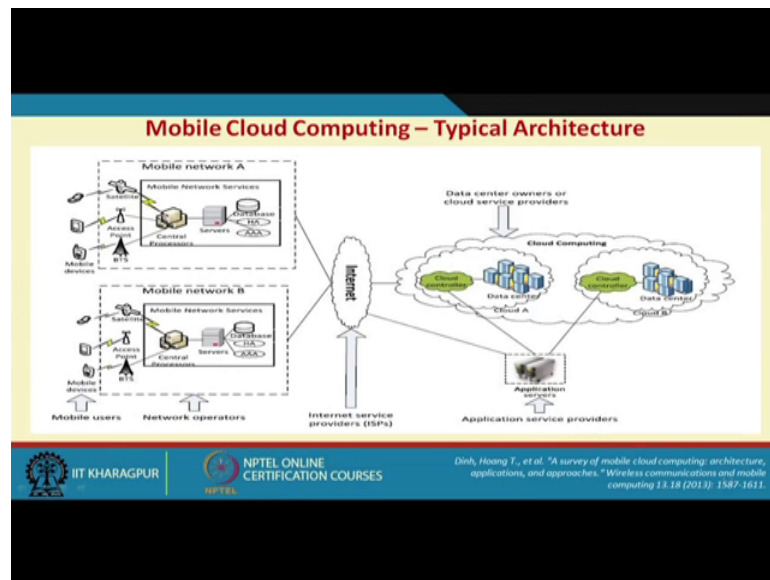
Key Requirements for MCC

- **Simple APIs** offering access to mobile services, and requiring no specific knowledge of underlying network technologies
- **Web Interface**
- **Internet access** to remotely stored applications in the cloud

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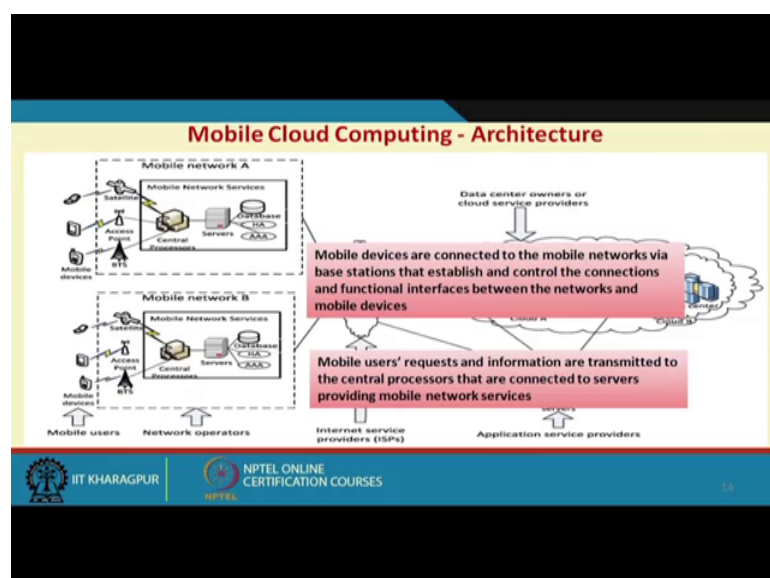
So, there are other components like requirements what we see that simple APIs, API should not be very cumbersome. So, that user is inclined to use it. So, simple API is offering access to mobile devices and requiring no specific knowledge of underlining network technologies right. So, it should be the user should not be burdened with the knowledge of network, technologies and knowing all those things wave interface should we should have a appropriate wave interface internet access to remotely stored applications in the cloud right. So, you should have internet access to remotely stored application in the cloud, that that is there.

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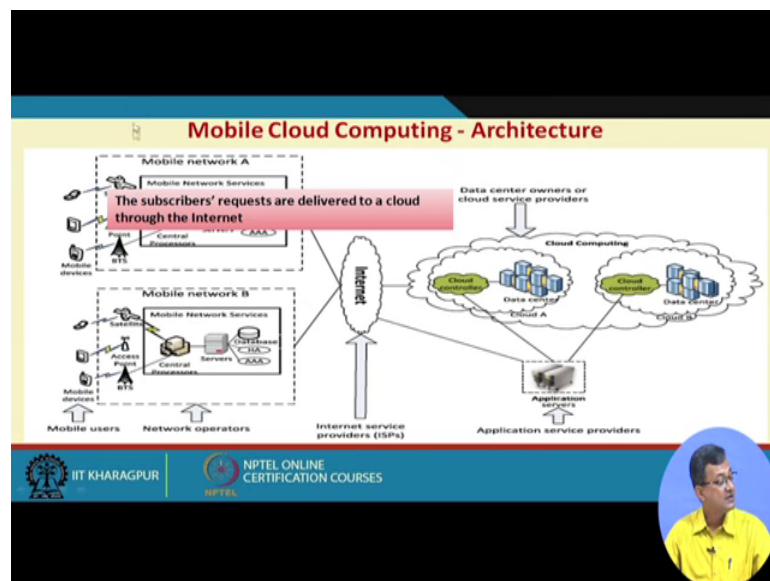
So, if we look at a typical architecture. So, one side we have mobile devices, one side this cloud computing environment and there are different service provider, which provides the network backbone and there are internet services to connect to this cloud right. So, therefore, the cloud it is more of a giving appropriate user interfaced were connecting this mobile devices or the applications, which are offloaded by the mobile devices onto the cloud. So, there are mobile user and network operators internet service provider and application service provider, so this which need to be appropriately working in sync right.

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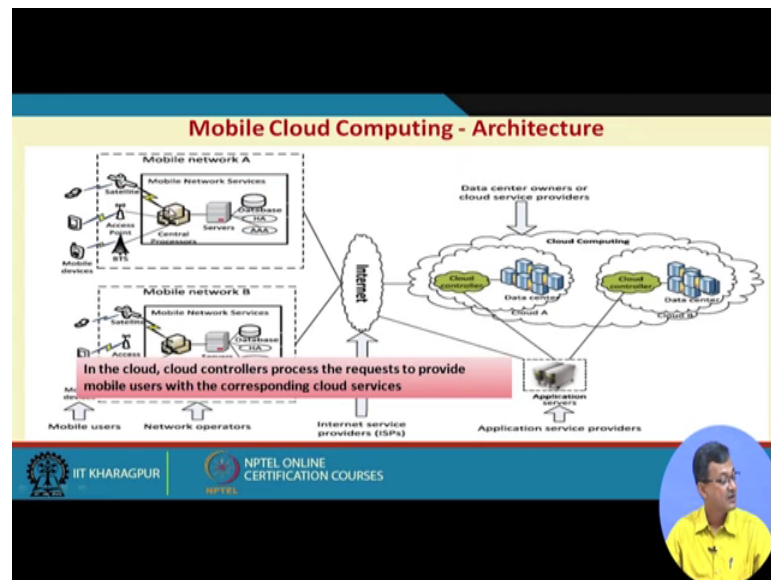
So, mobile devices are connected to the mobile networks via base stations and establish and control the connection of functional interface between the network and the mobile devices mobile user requires the information. So, one is that more devices connected to the base station, and mobile user requires the information are transmitted to the central possessing and are collected by the server providing those things, so that has to be are transmitted. So, there is a transmission of the data.

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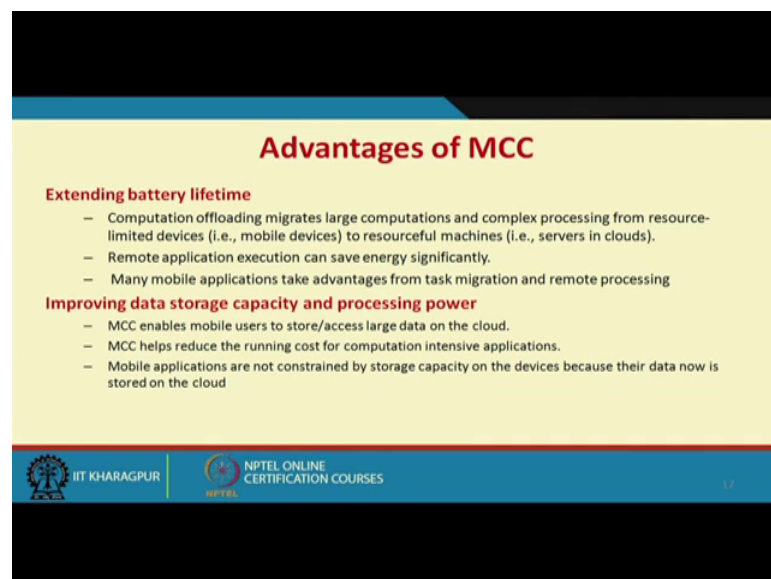
The subscriber requests are delivered to the cloud through the internet right the subscriber should be transparent to that.

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In the cloud, cloud controllers process the request to provide the mobile user with the corresponding cloud services. So, based on the request that cloud controller process the thing so that, it can give the mobile user the requested services.

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So, there are several advantages already we have looked into few of them and one is that extending battery life time. So, as you are off loading some computing thing, and which is if it is resource hungry, then in a sense you are saving energies and battery life time. Computation of loading migrates large computations and complex processing from

resource limited a device that is mobile devices to resource full machines that is servers in clouds right. Remote application execution can save energy sub secure significantly, many mobile application takes advantage from task migration and remote processing right. So, those are like helping saving battery life time improving data storage capacity and processing power right.

So, if it is a as it is stored on the cloud in with a huge amount of data storage capability. So, it improves that data storage capacity right I can go on continuously go on take data say, I am going on taking environmental data. So, and offloading it. So, that is no loading on my own devices. So, that is a there is a advantage of the things and of course, I have a huge processing power at the backend right provided my network latency is within the permissible limit right. Improve reliability and availability right.

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Advantages of MCC (contd...)

Improving Reliability and Availability

- Keeping data and application in the clouds reduces the chance of lost on the mobile devices.
- MCC can be designed as a comprehensive data security model for both service providers and users:
 - Protect copyrighted digital contents in clouds.
 - Provide security services such as virus scanning, malicious code detection, authentication for mobile users.
- With data and services in the clouds, then are always(almost) available even when the users are moving.

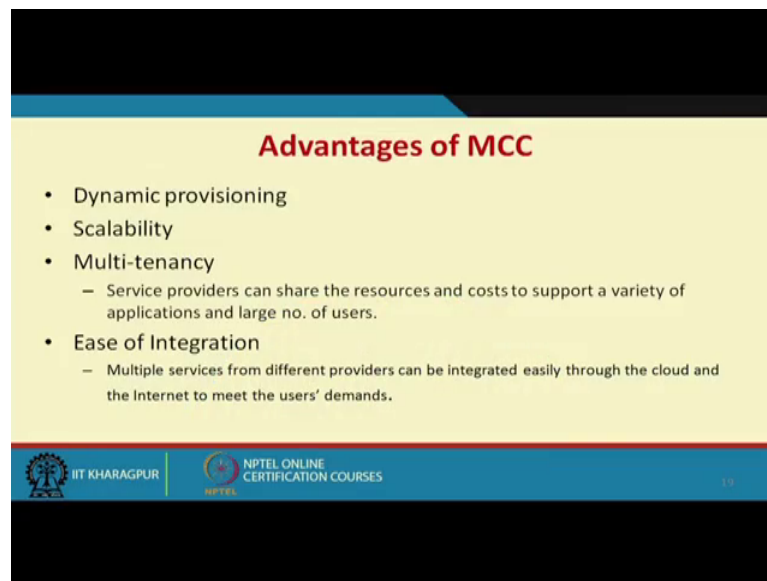
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So, that keeping data and application in the cloud reduces chance of loss of the data along with the mobile devices and thinks if there is a loss things are there. MCC can be designed as a comprehensive data security model for both service provider and users though there are lot of security issues, but the can be designed to look into like put it copyrighted digital content in the cloud or provide security services such as virus scanning malicious code detection etcetera. With data and services in the cloud then they there are always available within the when the users are moving right.

So, there is another thing is that, if the as the data and services are offloaded to the cloud. So, they are you omnipresent right, I can have always wherever I am moving whether this device if I have a sync with the other device or other things are accessing. So, it is always available in nothing, some sort of a having a centralized vision of services or processing services and data can be looked into.

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Advantages of MCC

- Dynamic provisioning
- Scalability
- Multi-tenancy
 - Service providers can share the resources and costs to support a variety of applications and large no. of users.
- Ease of Integration
 - Multiple services from different providers can be integrated easily through the cloud and the Internet to meet the users' demands.

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So, there are other advantages like a dynamic provisioning. So, I can dynamically provision the things, scalability issues like as whatever is provided by the cloud that is in finite scalable scalability, multi tenancy like service provider can share the resources and cost to support variety of application in large number of users like as there is a property of the cloud of multi tenant. Ease of integration, multiple services from different providers can be integrated easily through the cloud and the internet to meet the users demand right.

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Mobile Cloud Computing – Challenges

MCC Security Issues

Protecting user privacy and data/application secrecy from adversaries is key to establish and maintain consumers' trust in the mobile platform, especially in MCC.

MCC security issues have two main categories:

- Security for mobile users
- Securing data on clouds

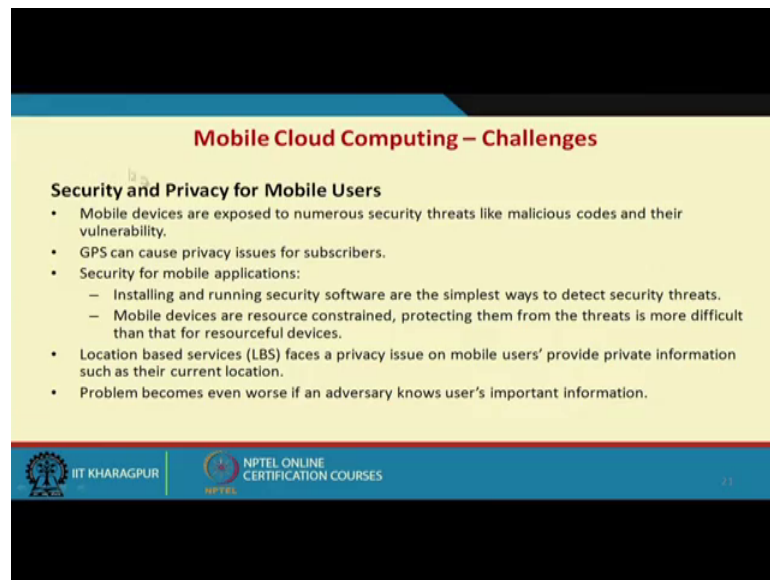
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So, that I can have standardized in one place, I can connect different devices and type of things in through the cloud and I can have integration of the things. There are several challenges one major challenges as we see in other cases also is security issues right. So, protecting user privacy day privacy and data application secrecy from adversaries is a key to establish and maintain consumer trust on mobile platform, especially in case of mobile cloud computing right.

So, how my data processing things are protected from other adversaries or attackers are is important, otherwise at least when a work on the devices I somewhat have a much larger trust on the devices, but if I once I offload, I do not know that what is happening. And most of the cases I am not subscribing to the cloud itself, I am subscribing to the service provider and the whole paradigm right it is offloading to the cloud, it may so happen that the whole framework may select different cloud, based on the availability pricing and different other factors, right.

So, it is sometimes becomes tricky issue on the security point. So, MCC security issues have two major categories like security of mobile users and securing data of cloud. So, privacy also plays the important role because in doing so, it is not only the data of the mobile user, but also my concerned maybe that my identity, my mobility, my GPS footprints are being tracked, right.

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Mobile Cloud Computing – Challenges

Security and Privacy for Mobile Users

- Mobile devices are exposed to numerous security threats like malicious codes and their vulnerability.
- GPS can cause privacy issues for subscribers.
- Security for mobile applications:
 - Installing and running security software are the simplest ways to detect security threats.
 - Mobile devices are resource constrained, protecting them from the threats is more difficult than that for resourceful devices.
- Location based services (LBS) faces a privacy issue on mobile users' provide private information such as their current location.
- Problem becomes even worse if an adversary knows user's important information.

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So, there are several issues; security and privacy of the mobile user that is why is a major issue. So, mobile devices can expose numerous security threats like malicious code and these, GPS can cause privacy issue of the subscribers. So, there are location based services faces privacy issue of the mobile user provide private information such as their current location etcetera.

Problem become worse if an adversary knows the users important information right; and security of the mobile users approach to move threat detection capabilities on the cloud. So, there are different types of approaches.

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Mobile Cloud Computing – Challenges

Security for Mobile Users

- Approaches to move the threat detection capabilities to clouds.
- Host agent runs on mobile devices to inspect the file activity on a system. If an identified file is not available in a cache of previous analyzed files, this file will be sent to the in cloud network service for verification.
- Attack detection for a smartphone is performed on a remote server in the cloud.
- The smartphone records only a minimal execution trace, and transmits it to the security server in the cloud.

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Host agent runs the mobile devices to inspect the file activity on the system, attack detection on a Smartphone is performed on a remote server on the cloud, it can be there like if there is a connectivity between the thing. So, there can be adversely affect the mobile user. The Smartphone records only a minimum execution trace and transmit it to the security server in the cloud right. So, that is another problem. So, mobile cloud computing there are other type other challenges like context aware mobile cloud services right.

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Mobile Cloud Computing – Challenges

Context-aware Mobile Cloud Services

- It is important to fulfill mobile users' satisfaction by monitoring their preferences and providing appropriate services to each of the users.
- Context-aware mobile cloud services try to utilize the local contexts (e.g., data types, network status, device environments, and user preferences) to improve the quality of service (QoS).

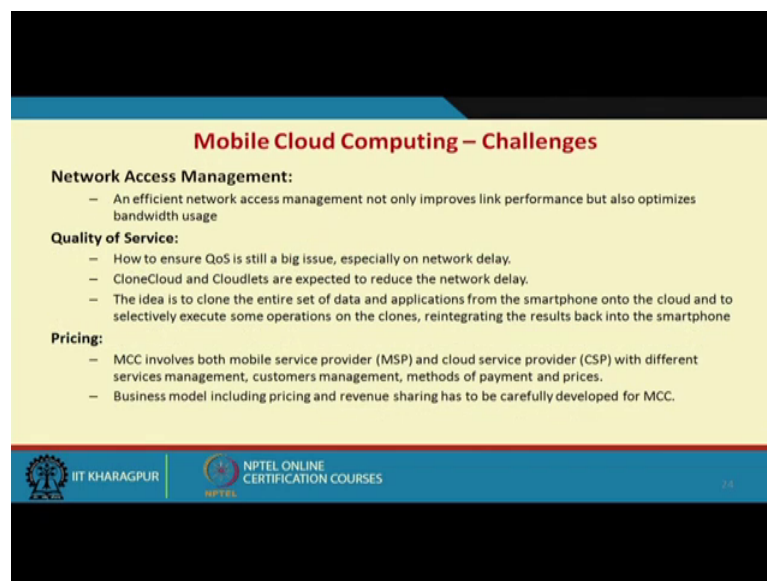
H. H. La and S. D. Kim, "A Conceptual Framework for Provisioning Context-aware Mobile Cloud Services", in Proceedings of IEEE International Conference on Cloud Computing (CLOUD), pp. 466, August 2010.

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So, this is context our aware services of the mobile users are there a lot of research is going on. Like it is important to fulfil mobile user satisfaction, by monitoring their preferences and providing appropriate services to each of the users right. So, different users after all is human being, has different way of looking at thing. So, I need to categorize that what sort of users are which type of things like some are maybe looking at more streaming multimedia things, some are more used to having some sort of a mail and data services and type of things right some of the users right may be running some scientific things likes say data analysis type of thing.

So, this type of different user has different type of need at the back end. So, that services is based on that or based on the context need to be looked at right. So, context aware mobile cloud services try to utilize the local context, that is the data types network status device environment, user preferences to improve the quality of services right.

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Mobile Cloud Computing – Challenges

Network Access Management:

- An efficient network access management not only improves link performance but also optimizes bandwidth usage

Quality of Service:

- How to ensure QoS is still a big issue, especially on network delay.
- CloneCloud and Cloudlets are expected to reduce the network delay.
- The idea is to clone the entire set of data and applications from the smartphone onto the cloud and to selectively execute some operations on the clones, reintegrating the results back into the smartphone

Pricing:

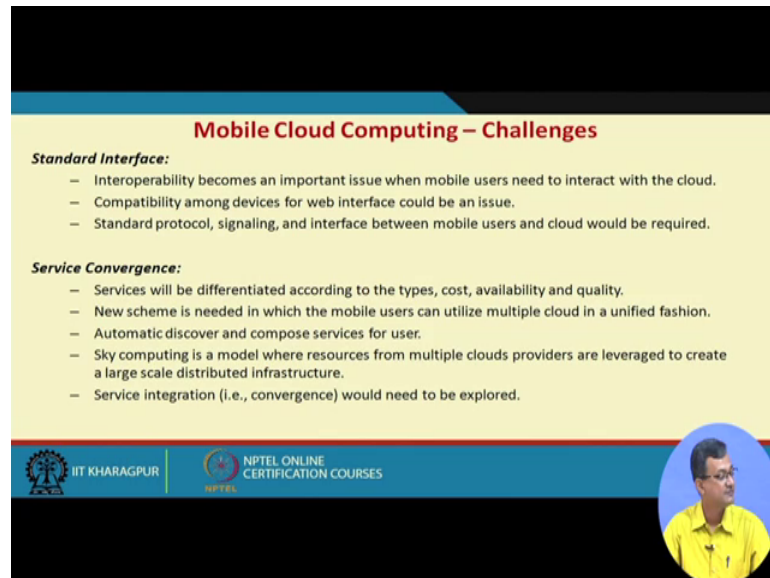
- MCC involves both mobile service provider (MSP) and cloud service provider (CSP) with different services management, customers management, methods of payment and prices.
- Business model including pricing and revenue sharing has to be carefully developed for MCC.

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Network access management this another challenge; like a if we see a network access management only to improve link performance and also optimizes bandwidth usage. So, what is this network latency is plays a major bottleneck. So, it is not only improving the bandwidth network giving latency, but how to optimize those uses after all these are resources which are being used by several users right. Quality of service is another aspects pricing is a tricky issue right.

So, there are number of parties now involved, it is not only the cloud provider it is a mobile service provider also. So, how this price will be there, what should be the business model and how to make use of the price, where a user will pay and what benefit is get, what is the SLAs and how things are served those are very tricky and very important issues and challenges.

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Mobile Cloud Computing – Challenges

Standard Interface:

- Interoperability becomes an important issue when mobile users need to interact with the cloud.
- Compatibility among devices for web interface could be an issue.
- Standard protocol, signaling, and interface between mobile users and cloud would be required.

Service Convergence:

- Services will be differentiated according to the types, cost, availability and quality.
- New scheme is needed in which the mobile users can utilize multiple cloud in a unified fashion.
- Automatic discover and compose services for user.
- Sky computing is a model where resources from multiple clouds providers are leveraged to create a large scale distributed infrastructure.
- Service integration (i.e., convergence) would need to be explored.

The slide footer includes the IIT Kharagpur logo, the text 'IIT KHARAGPUR', the NPTEL logo, and the text 'NPTEL ONLINE CERTIFICATION COURSES'. A circular inset image of a man in a yellow shirt is visible in the bottom right corner.

There are other challenges like standard interfaces. So, that you can provide a challenge a standard interfaces or different applications, different sort of devices can work on it. Service convergence, services will be differentiated according to the type cost availability and quality. New scheme is needed in which the mobile user can utilize multiple cloud in a unified fashion. So, that is what we mean by service conversion. Service integrated that convergence would need to be explored in order to achieve all those things right. So, these are some of the important aspects of the things.

So, what we see definitely there is a need and it is a increasing need right day to day things are increasing that you want to run more stronger application or resource hungry application on the mobile devices. So, we need at the back end something a good infrastructure, which can work on behalf of my devices right. So, cloud is one of the definitely one of the option one of the good option of doing that and. So, what we required this there should be a seamless integration of this devices with the cloud service

providers and in between we have this network service provider or the who provides the mobile services and things.

So, one side mobile devices, one side cloud and intermediate this network services including internetworking, which can put all together to all of them together and so that I can have a enriched applications or more resource full applications running on devices and doing lot of other application a lot of job for variety of users.

So, with this we will conclude today.

Thank you.