

* Support For Mobility

* Mobile Databases

- A database is a collection of systematically stored records or information.
- Mobile computing devices (ex- smartphones & PDAs) store and share data over a mobile n/w, or a database which is actually stored by mobile device. This could be a list of contacts, price information, distance travelled or any other information.
- Many applications require the ability to download information from an info repository and operate on this info. even when out of range or disconnected. This type of access and work load generated by such users is different from traditional workloads seen in client-server systems of today.
- Caching entails saving a copy of select data or a part of a database from a connected system with a larger database. The cached data is hoarded in the mobile device database. Hoarding of the cached data in the database ensures that even when the device is not connected to the n/w, the data required from the database is available for computing.

* Database Hoarding / Data Hoarding

- A mobile device - not always connected to the server or n/w, neither does the device retrieve data from a server or a n/w for each computation.
- Rather, the device caches required specific data, which may be required for future computations, during the interval in which device is connected to server/n/w.
- Database hoarding may be done at application tier itself.
- IBM DB2 Everyplace (DB2e) is a relational database engine which has been designed to reside at the device. It supports J2ME and most mobile device OS. DB2e synchronizes with DB2 databases at the synchronization, application, or enterprise level.
- A cache is a list or database items or records stored at the device. Databases are hoarded at the app^ or enterprise tier, where the database server uses business logic & connectivity for retrieving the data and then transmitting it ~~at~~^{to} the device. The server provides & updates local copies of the database at each mobile device connected to it.
- The computing API at the mobile device (first tier) uses the cached local copy. At first tier, API uses cached data records using computing architecture. ~~for~~ From tier 2 (app^ server) or tier 3 (enterprise server), the server retrieves & transmits the data records to tier 1 using business logic & synchronizes the ~~copy~~ local copies at the device. These local copies funcⁿ as device caches.

Advantages:

- No access latency (delay in retrieving the queried record from the server over wireless mobile networks)
- The client device API has instantaneous data access to hoarded or cached data.
- After a device caches the data distributed by the server, the data is hoarded at the device.

Disadvantage:

- Consistency of the cached data with the database at the server needs to be maintained.
- A client device caches the pushed (disseminated) data records from a server. Caching of the pushed data leads to a reduced access interval as compared to the pull (on-demand) mode of data fetching. Caching can be based on the ratio of two parameters - access probability (at the device) and pushing rates (from the server) for each record. This method is called cost-based data replacement or caching.
- Pre-fetching is another alternative to caching of disseminated data. The process of pre-fetching entails requesting for and pulling records that may be required later.
- Cache invalidation is a process by which a cached data item or record becomes invalid and thus unusable because of modification, expiry, or invalidation at another computing system or server. Cache invalidation mechanisms are used to synchronize the data at other processors whenever the cache-data is written (modified) by a processor in a multiprocessor system, cache invalidation mechanisms are also active in case of mobile devices having distributed copies from server.
- A cache consists of several records. Each record is called a cache-line, copies of which can be stored at other devices or servers. Cache can be assigned one of four possible tags indicating its state - modified (after rewriting), exclusive, shared, and invalidated (after expiry or when new data becomes available) at any given instance. These four states are indicated by letters M, E, S, I resp (MESI).
- ~~Cache coherence requirement / cache consistency requires consistency mechanism~~
- Cache consistency (cache coherence) requires a mechanism to ensure that a database record is identical at server as well as at device caches & that only the valid ~~recd~~ cache records are used for computations. Four possible invalidation mechanisms are :- stateless asynchronous, stateless synchronous, stateful async & stateful sync
- stateless Asynchronous
 - A stateless mech. entails broadcasting of invalidation of cache to all clients of the server. 'Asynchronous' indicate that invalidation info. for an item is sent as soon as its value changes. The server does not keep the info of present state (E_{ini} , M_{ini} , S_{ini} , or I_{ini}) of a data-record in cache for broadcasting later. The

- server advertises the invalidation info. only.
- Advantage: # No frequent, unnecessary transfers of data reports thus making mech. more bandwidth efficient.
- Disadvantage: # Every client device gets an invalidation report, whether that client requires that copy or not.
Client devices presume that as long as there is no invalidation report, the copy is valid for use in computations.
- Stateless Synchronous
- Here the server advertises invalidation info. at periodic intervals as well as whenever the corresponding data-record at server is invalidated or modified. This method ensures synchronization because even if the in-between period report is not detected by the device due to a link failure, the device expects the period-end report of invalidation and if that is not received at end of the period, then the device sends a request for the same (deleted or replaced).
- Advantage: # Client devices receive periodic info regarding invalidity of data cache.
Thus, greater reliability of cached data.
Maintain cache consistency
- Disadvantage: # Unnecessary transfers of data invalidation reports take place.
Every client device gets an advertised invalidation report periodically.
During period b/w two invalidation reports, client device assumes that, as long as there is no invalidation report, copy is valid for use in computations.
- Stateful Asynchronous
- 'Stateful' indicates that cache invalidation reports are sent only to the affected client devices and not broadcasted to all. The server stores the info. regarding the present state of each data record at client device caches. This state info. is stored in Home loc' cache (HLC) at server. The HLC is maintained by an HA (Home Agent) slw.
- Client device informs HA of state of each record to enable storage of the same at the HLC. The server transmits invalidation info as and when records are invalidated & it transmits only to device-clients which are affected by the invalidation of data. After the data records transmitted by server modify the client device cache, the device sends info about new state to the server & that record of cache-states at server is also modified.
- Advantage: # Server keeps track of state of cached data at client device.
Only affected clients receive invalidation reports and other devices are not flooded with irrelevant reports.
- Disadvantage: # Client devices presume that, as long as there is no invalidation report, the copy is valid for use in computations.
When there is a link failure, then devices use invalidated data.

- Stateful Synchronous
 - The server keeps the info ~~the~~ of the present state of data-records at the client-caches. The server stores the cache record state at HLC using the HA.
 - The server transmits invalidation info. at periodic interval to the clients & whenever the data-record relevant to client is invalidated or modified (deleted or replaced) at the server.
 - This method ensures synchronization because even if ~~if~~ the in-blw period report is not detected by device due to link failure, device expects the period-end report of invalidation and if it is not received at the end of the period, then the device requests for the same.
 - Advantage: # There are reports identifying invalidity & thus, invalidity, of validity of data caches at periodic intervals of the server also periodically updates the client-cache states stored in the HLC.
 - Disadvantage: # High bandwidth requirement.

* Data Cache Maintenance in Mobile Environments (Caching)

- A request must be sent to server for data record, & this mechanism is called pulling. The time taken for appln to access a particular record is called access latency. Caching of hoarding record at device reduces access latency to zero.
- Data ^{cache} inconsistency means that data records cached for appln's are not invalidated at the device when modified at server but not modified at device. Data consistency can be maintained by three methods:
 - Cache invalidation mechanism (server-initiated case)
 - Polling mechanism (client-initiated case): Polling means checking from server, the state of data record whether record is in the valid, invalid, modified or exclusive state.
(for internal use only)
 - Time-To-Live (TTL) mechanism (client-initiated case): Each cached record is assigned a TTL. TTL assignment is adaptive (adjustable) previous update intervals of that record. After end of TTL, cached record copy is polled. If modified, device requests server.
- web cache maintenance is necessary in a mobile environment to overcome access latency in downloading from websites due to disconnections. It can be maintained by web cache consistency which can be maintained by two methods :

- TTL Mechanism (Client-initiated case)
 - Power-aware computing mechanism (client-initiated case): Each web cache maintained at device can also store CRC (Cyclic Redundancy Check) bits. Whenever any of the recorded cache is modified, corresponding CRC bits at server are also modified.
- ~~After TTL expires or on-demand for web cache records by client API,~~

the cached records CRC is polled & obtained from website server. If CRC at client end is found modified & change is much higher than given threshold, client retrieves it from server. If minor change, API uses previous cache.

* Client-Server Computing

- Client-server computing is a distributed computing architecture, in which there are two types of nodes, i.e., clients & servers. A server is defined as a computing system, which responds to request from one or more clients. A client is defined as a computing system, which requests server for a resource or for executing a task.
- Client-server architecture can have N-tier architecture ($N=1, 2, 3, \dots$).
- Two-tier Client-server architecture: ## Server synchronizes with ~~client~~ mobile devices.
Synchronization means when copies of records at server-end are modified, the copies cached at client devices should also be accordingly modified.
- Three-tier Client-server architecture: ## In 3-tier architecture, the applⁿ interface, the functional logic, & the database are maintained at three different layers. The database connects to the enterprise server through a connecting protocol. The enterprise server connects the complete database on different platforms, for ex, Oracle, XML etc.
- N-tier Client-Server architecture: ## When N is greater than 3, then the database is presented at the client through in-between layers.

- Context-aware Computing

- A context-aware computing is one which has user, device, & applⁿ interfaces such that, using these, the system remains aware of past and present surrounding situations, circumstances, or actions such as present mobile netw, surrounding devices or systems, changes in the state of connecting netw, physical parameters, such as present time of day, presently remaining memory & battery power, etc., and takes these into account during computations.
- 'Context' refers to the interrelated cond's in which a collection of elements, records, components, or entities exists or occurs.
- Physical Context, Computing Context, User Context, Temporal Context, Structural Context
- A transaction is the execution of interrelated instructions in a sequence - for a specific operation on a database. Database transaction models must maintain data integrity & must enforce a set of rules called ACID rules (Atomicity, Consistency, Isolation, Durability).

* Data Recovery Process

- Data is non-recoverable in case of media failure, intentional attack on the database and transactions logging data, or physical media destruction. However, data recovery is possible in other cases.
- Recovery management architecture uses a recovery manager, which ensures atomicity & durability. Database (buffer) manager processes the queries during a transaction & uses a database buffer.

- The recovery manager uses a log file, which logs actions. A procedure called the ARIES algorithm is also used for recovering lost data. Basic steps of algo are:
 - i) analyze from last checkpoint & identify all dirty records.
 - ii) Redo buffer operations logged in update log to finish & make final page
 - iii) Undo all write operations & restore pre-transaction values.
- The recovery models used in data recovery processes are as follows:
 - i) The full recovery model creates backup of database & incremental backup of the changes.
 - ii) The bulk-logged recovery model entails logging & taking backup of bulk data record operations but not full logging & backup.
 - iii) The simple recovery model prepares full backups but incremental changes are not logged.
- * Data Dissemination
 - Data dissemination is the distribution or transmitting of statistical, other, data to end users.
 - There are many ways organisations can release data to public, i.e., electronic format, CD-ROM or paper publications such as PDF files based on aggregated data.
 - The most popular dissemination method today is the 'non-proprietary' open-systems using internet protocols.
 - Data dissemination entails distributing and pushing data generated by a set of computing systems or broadcasting data from audio, video, and data services. The O/P data is sent to the mobile devices. A mobile device can select, tune and cache the required data items, which can be used for appln programs. Data disseminated through broadcast channels can be simultaneously accessed by an arbitrary no. of mobile users, thus increasing efficiency of bandwidth usage.
 - One key aspect of dissemination-based applications is their inherent communication asymmetry, i.e., the communication capacity or data volume in the downstream direction (server to client) is much greater than in upstream direction (client to server).
 - There are three kinds of broadcast models : push-based broadcast, on-demand (or pull-based) broadcast, and hybrid broadcast.
 - In ~~push-based broadcast~~ - In push-based broadcast, server disseminates info. → In this, the server dis using a periodic/aperiodic broadcast program (generally without any intervention of clients).
 - In on-demand ~~broadcast~~, the server disseminates information based on the outstanding requests submitted by clients.

- In hybrid broadcast, both combined to complement each other.
- Data-delivery mechanisms can be classified into three categories:
 - i) Push-based / Publish-subscribe mode
 - Data records are pushed to mobile devices by broadcasting without any demand.
 - It func as follows:
 - a structure of data records to be pushed is selected
 - b data is pushed at selected time intervals using an adaptive algorithm
 - c bandwidths are adapted for downlink (for pushes) using an algorithm
 - d A mechanism is also adopted to stop pushes when a device is handed over to another cell.
 - ii) Pull-based / On-Demand Mode
 - It func as follows:
 - a bandwidth used for uplink channel depends upon the number of pull requests
 - b A pull threshold is selected (no. of requests in given period of time)
 - c A mechanism is adopted to prevent device from pulling from a cell, which has handed over the concerned device to another cell.
 - iii) Hybrid / Interleaved-push-and-pull (IPP) mechanism → It func as follows:
 - a There are two channels, one for pushes by front channel & other for pulls by back channel.
 - b Bandwidth is shared & adapted b/w two channels depending upon no. of active devices receiving data from server & no. of devices requesting data pulls from server.
 - c An algorithm can adaptively chop the lowest level of scheduled pushes successively.
- Selective Tuning & Indexing Techniques
 - Selective tuning is a process by which client device selects only the required pushed buckets or records, tunes to them and caches them. Tuning means getting ready for caching at those instants and intervals when a selected record of interest broadcasts.
 - One of Directory method
 - # One of the methods for selective tuning involves broadcasting a directory as overhead at the beginning of each broadcast cycle.
 - Hash-Based Method
 - # Hash is a result of operations on a pair of key & record. Advantage of broadcasting a hash is that it contains a fewer bits compared to key & records separately.
 - Index-Based Method
 - # Indexing is another method for selective tuning. Indexes temporarily map the loc' of the bucket. At each locn, besides the bits for the bucket in record of interest data, an offset value may also be specified there.
 - Distributed Index-Based Method
 - # If is an improvement on the (I,m) method. In this method, there is no need to repeat the complete index again & again. Instead of replicating whole index m times, each index segment in a bucket describes only set I' of data items which immediately follow.

>Flexible Indexing Method

Assume that broadcast cycle has m set of records (called segments). A set of binary bits defines the index parameter I_{seg} . A local index is then assigned to the specific record (or bucket). Only local index (I_{rec} or I_b) is used in (I_{loc}, m) based data tuning which corresponds to the case of flexible indexing method.

- Alternative methods

- Temporal Addressing: It is a technique used for pushing in which instead of repeating I several times, a temporal value is repeated before a data record is transmitted.
- Broadcast Addressing: It uses a broadcast address similar to IP or multicast address. Each device or group of devices can be assigned an address.
- Use of Headers: A server can broadcast a data in multiple version or ways. An index or address only specifies where data is located for purpose of tuning. It does not specify details of data at the buckets.
- (1,m) index: It is an index allocation method where a complete index is broadcast m times during a broadcast.
- Tree-based Index / Distributed Indexing Scheme: In this scheme a data file is associated with a B^+ -tree index structure. Since broadcast medium is a sequential medium, the data file & index must be flattened so that data ~~are~~ index are broadcast following a preorder traversal of the tree.
- Flexible Indexing Scheme: This scheme splits a sorted list of objects into equal-sized segments, and provides indexes to navigate through the segments. At the beginning of each segment, there is a control index which comprises of two components : a global index and a local index.

* User Agent Profile (UA Prof)

- The UAProf (User Agent Profile) specification is concerned with capturing capability & preference information for wireless devices. This info. can be used by content providers to produce content in an appropriate format for the specific device.
- UAProf files typically have the file extensions .rdf or .xml, and are usually served with mimetype application/xml.
- A UAProf file describes the capabilities of a mobile handset, including vendor, Model, Screen Size, Multimedia Capabilities, character set support and more.

* Service Discovery

- Service Discovery is the automatic detection of devices and services offered by these devices on a computer network.
- A service discovery protocol (SDP) is a new protocol that helps accomplish service discovery.
- Service discovery requires a common language to allow new agents to make use of one another's services without the need for continuous user intervention.
- There are many service discovery protocols, including:
 - Bluetooth Service Discovery Protocol (BSDP)
 - DNS Service Discovery (DNS-SD), a component of Zero Configuration Networking
 - Dynamic Host Configuration Protocol (DHCP)
 - Internet Storage Name Service (iSNS)
 - Jini for Java objects

* Data Management Issues in Mobile Computing

- Mobility:
 - The search cost to locate mobile elements is added to the cost of each communication involving them.
 - Efficient data structures, algorithms, and query execution plans must be devised for representing, managing, and querying the loc'n of mobile elements, which is a fast changing data
- Wireless Medium:
 - wireless nets are more expensive, offer less bandwidth, and are less reliable than wireline nets.
- Portability:
 - Mobile elements must be light and small to be easily carried around
 - Such considerations, in conjunction with a given cost & level of technology will keep mobile elements having less resources than static elements, including memory, screen size and disk capacity.
- Limitations:
 - Range and Bandwidth → Security Standards
 - Power Consumption → Transmission Interferences
 - Potential Health Hazards
 - Human Interface with device

* Data Replication for Mobile Computers

- Replication in computing involves sharing information so as to ensure consistency b/w redundant resources, such as S/w or h/w components, to improve reliability, fault-tolerance or accessibility.
- Types: → 'active replication' is performed by processing the same request at every replica.
 - 'passive replication' involves processing each single request on a single replica & then transferring its resultant state to the other replicas.
- Models: → Transactional Replication: This is the model for replicating transactional data, for example a database or some other form of transactional storage structure. The one-copy serializability is employed in this case.
 - State Machine Replication: This model assumes that replicated process is a deterministic finite automation & that atomic broadcast of every event is possible. It is based on a distributed computing problem called distributed consensus & has a great deal in common with transactional replication model.
 - Virtual Synchrony: This computational model is used when a group of processes cooperate to replicate in-memory data or to coordinate actions.

* Database Replication for Mobile Computer

- Database replication can be used on many DBMS, usually with a master/slave relationship b/w original & the copies. The master logs the updates, which then ripple through to the slaves. The slave ~~sends~~ ^{outputs} a msg. stating that successful update reception, thus allowing subsequent updates sending.
- ~~Master~~ Multi-master replication is, where updates can be submitted to any database node, & then ripple through to other servers, is often desired. The most common challenge to this is transactional conflict prevention or resolution.
- Disk Storage Replication
 - Active (real-time) storage replication is usually implemented by distributing updates of a block device to several physical hard disks. The main characteristic is how write operations are handled:
 - # Synchronous Replication
 - # Asynchronous Replication

Semi-Synchronous Replication.

Point-in-time replication (Snapshot)

- File Based Replication

→ It is replicating files at logical level rather than replicating at the storage block level. The solⁿ almost exclusively rely on S/W.

Capture with a Kernel Driver

with the use of kernel driver, that intercepts calls to the file system func's, any activity is captured immediately as it occurs.

File System Journal Replication

Similar to DB transaction logs, many file systems have ability to journal their activity. The journal can be sent to another machine, either periodically or in real time by streaming. On the replica side, the journal can be used to play back file system modifications.

Batch Replication

This is the process of comparing source & dest. file systems ~~to have the ability~~ and ensuring that the dest. matches the source.

- Distributed Shared Memory Replication

→ Many nodes of system share same page of memory?

- Primary-Backup & Multi-Primary Replication

→ Many classical approaches to replication are based on primary/backup model where one device or process has unilateral control over one or more other processes or devices.

→ A weakness of primary/backup schemes is that in settings where both processes could have been active, only one is actually performing operations.

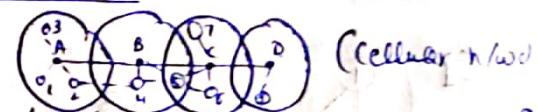
* Adaptive Clustering for Mobile Wireless N/wks.

- The Multiclusiter Architecture

→ A major challenge in multihop, multimedia n/w is the ability to account for resources so that bandwidth reservations can be placed on them. In Cellular (single hop) n/w's such accountability is made easy by fact that all stations learn of each other's requirements, either directly or through a ctrl station.

→ This solⁿ can be extended to multihop n/w's by creating clusters of radios in such a way that access can be controlled f bandwidth can be allotted in each cluster.

→ Most hierarchical clustering architectures for mobile radio n/w's are based on concept of 'clusterhead'. The clusterhead acts as a local coordinator of transmissions within cluster. It does extra work w/ ordinary stations, f thus it can become bottleneck of cluster. To overcome this, we



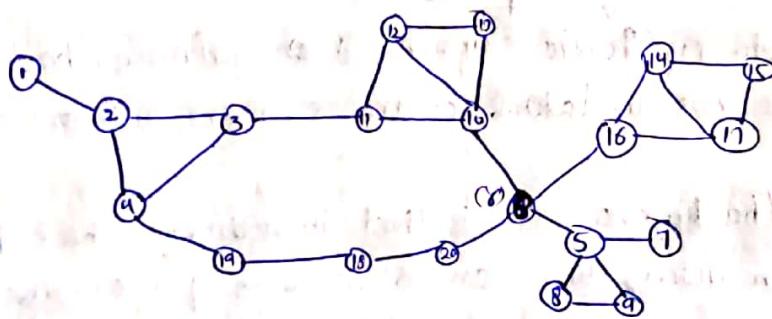
eliminate requirement for a cluster head altogether & adopt a fully distributed approach for cluster formation & intra-cluster communications.

→ The clustering algorithm is to find an ~~inter~~ interconnected set of clusters covering the entire node population. The system topology is divided into small partitions (clusters) with independent control. Within a cluster, it should be easy to schedule pkt transmissions & to allocate bandwidth to real time traffic. Across clusters, the spatial reuse of codes must be exploited. Since there is no cluster head, each node within a cluster is treated equally. This permits to avoid vulnerable centers of hotspots of pkt traffic-flow.

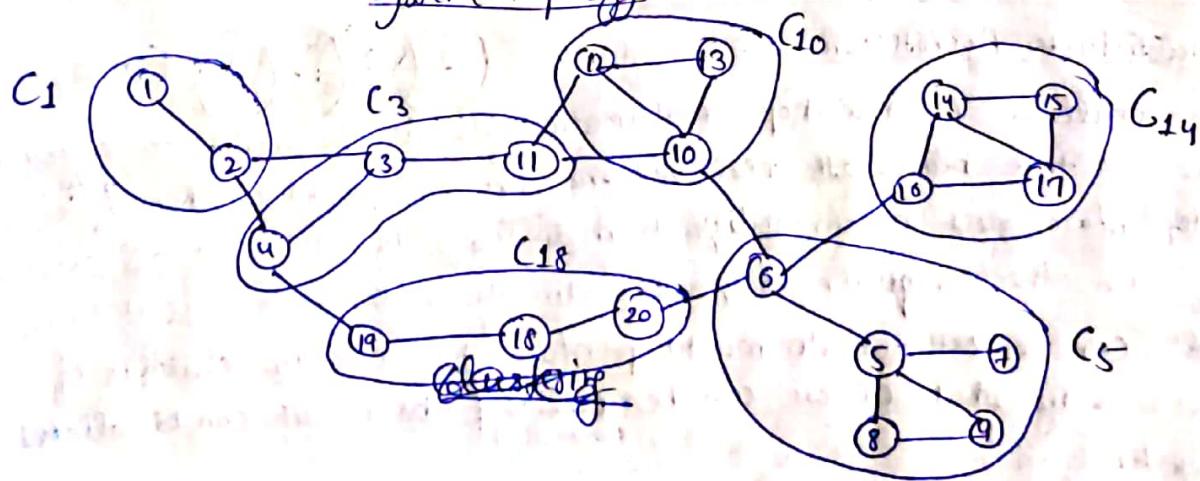
The Clustering Algorithm

→ In order to support multimedia traffic, wireless nlw layer must guarantee QoS to real time traffic components. Our approach to provide QoS to multimedia consists of following two steps:

- partitioning of multihop nlw into clusters, so that controlled, accountable bandwidth sharing can be accomplished in each cluster.
- establishment of virtual circuits with QoS guarantee.



System topology



Clustering

* Mobile Devices and File Systems / Mobile File System

- Mobile file Management (MFM) is a type of information technology (IT) s/w that allows businesses to manage transfer & storage of corporate files and other related items on a mobile device and allows business to oversee user access.
- A mobile file system is a client/server-based application that allows clients to access & process data stored on server as if it were on their own computer.
- When a user accesses a file on the server, the server sends user a copy of the file, which is cached on the user's computer while data is being processed & is then returned to the server.
- Ideally, a mobile file system organizes file and directory services of individual servers into a global directory in such a way that remote data access is not locⁿ-specific but is identical from any client.
- All files are accessible to all users of the global file system and organization is hierarchical & directory-based.
- Since more than one client may access the data simultaneously, the server must have a mechanism in place (such as maintaining info. about times of access) to organize updates so that the client always receives the most current version of data and that data conflicts do not arise.
- A main advantage is that they do not need a VPN conn. for mobile devices to connect to corporate file servers. The conn. b/w mobile device & corporate file server is established via a cloud service. The files are transferred highly encrypted, ex., accn to AES 256-bit industry standard.
- File management is how the computer OS keeps data organized through use of files & folders, how they are arranged, and how they are listed in a hierarchical order. MFM allows file management to be used on tablet computers. By installing it both on tablet & corporate server, users of mobile devices can freely access corporate servers from remote locⁿs.

* Data Synchronization

- Data synchronization technologies are designed to synchronize a single set of data b/w two or more devices, automatically copying changes back & forth.
- Data synchronization can be 'local synchronization' where device & computer are side-by-side & data is transferred or 'remote synchronization' where a user is mobile & data is synchronized over a mobile n/w.
- Models:
 - One to Many: Each system or device caches the ~~pushed~~ data pushed from the server or sends a pull request to central server & get response.
 - Many to Many: Employs peer-to-peer architecture where each system is capable of sending pull requests & of pushing responses.

* Synchronization Markup Language (SyncML)

- SyncML is the former name for a platform-independent information synchronization standard. The project is currently referred to as 'Open Mobile Alliance Data Synchronization and Device Management'.
- The purpose of SyncML is to offer an open standard as a replacement for existing data synchronization Sol's, which have mostly been somewhat vendor-, appln-, or OS-specific.
- SyncML works by exchanging Cmds, which can be requests and responses. As an example:
 - The mobile sends an Alert cmd for signalling wish to begin a refresh-only synchronization.
 - The computer responds with a Status cmd for accepting the request
 - The mobile sends one or more Sync cmd containing an Add sub-cmd for each item (ex; phonebook entry); if the no. of entries is large, it does not include the <Final/> tag;
 - In the latter case, the computer requests to continue with an appropriate Alert msg, & the mobile sends another chunk of items; otherwise, the computer confirms it received all data with a Status cmd,

* Wireless Devices and Operating Systems

- PDA (Personal Digital Assistant)

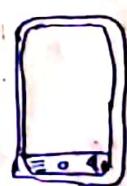
- A PDA, also known as a palmtop computer, or personal data assistant, is a mobile device that func's as a personal info. manager.
- PDAs are largely considered obsolete with widespread adoption of smartphones.
- Common current PDAs are able to connect to internet.
- Most PDAs uses touch screen technology.
- In 1984, Psion released the first "PDA", Organizer II. In 1991 followed by Psion's Series 3, which began to resemble familiar PDA style. It ~~had~~ also had a full keyboard.



PDA

- Smartphone

- A smartphone is a mobile phone built on a mobile OS, with more advanced computing capability & connectivity than a feature phone.
- The first smartphones were a combination of PDA & a mobile phone functionality.

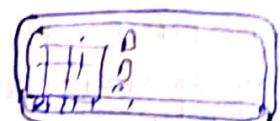


Smartphone

- Some functions were added in later models like portable media players, low-end compact digital cameras, pocket video cameras, & GPS navigation units, form one multi-use device, high-resolution touchscreens and web browsers for displaying standard web sites of mobile-optimized pages. Also, Wi-Fi provided high-speed data access of mobile broadband.
- The most usual mobile OS used by modern smartphones include Google's Android, Apple's iOS, Nokia's Symbian, RIM's BlackBerry OS, Samsung's BADA & Microsoft Windows Phone.

- Tablet Computer

- Tablet computers are larger than a mobile phone or PDA. They are type of mobile devices integrated into a flat touch screen & primarily operated by touching the screen. No physical keyboard is placed in them.
- It often uses an onscreen virtual keyboard, a passive stylus pen, or a digital pen. Normally, tablet does not have an integrated keyboard but they can be connected to a wireless or USB keyboard, while notebook computers have an integrated keyboard that can be hidden by a slide joint.
- In hybrid models a detachable keyboard is included so that the touch screen can be used as a stand-alone tablet. Booklets include dual-touchscreen. One of them is used as a virtual keyboard.
- Apple released the iPad with OS of touchscreen technology in 2010 & became the first successful mobile computer tablet to achieve worldwide commercial success.



Tablet Computer

- Ultra-Mobile PC(UMPC)

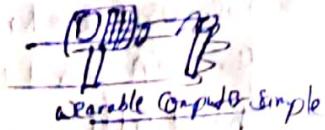
- An UMPC is a small form factor version of a pen computer, a class of laptop whose specifications were launched by Microsoft & Intel in spring 2006.
- The 1st gen UMPCs were just simple PCs with Linux or an adapted version of Microsoft's tablet PC OS.
- 2nd gen UMPCs use less electricity & can therefore be used longer (upto 5 hrs) & also support Windows Vista.



UMPC

- Wearable Computers

- Wearable computers, also known as body-borne computers, are miniature electronic devices that are be worn by the bearer under, with or on top of clothing. This class of wearable technology has been developed for general or special purpose info. technologies & media development.



wearable computer, simple

- Wearable computers are especially used for appl's that require more complex computational support than just b/w coded logics.
- One of the main features of a mobile computer is consistency.
- Many issues common to the wearable computer include power management, and heat dissipation, SW architectures, wireless & PANs.

* Mobile OS

- Symbian

- Symbian is a mobile OS designed for smartphones originally developed by Symbian Ltd. but currently maintained by Accenture. The Symbian platform is the successor to Symbian OS and Nokia Series 60.
- The latest version, Symbian ver. 3, was officially released in Q4 2010 & first used in the Nokia N8.
- The 1st Symbian phone, the touchscreen Ericsson R380 smartphone was released in 2000 and was first device to be marketed as a 'smartphone'. It combined a PDA with a mobile phone.
- Later in 2000, the Nokia 9210 communicator was released, also with Symbian. The late 9500 was Nokia's first camera phone & first Wi-Fi phone.
- In 2010, Nokia released Nokia N8 smartphone with a stylus-free capacitive touchscreen, the 1st device to use new Symbian 3 OS. Its megapixel camera able to record HD video in 720p. It also featured a front-facing VGA camera for videoconferencing.
- Mobile device shipped with Symbian OS up to end of Q2 2010 is 385 million. No. 1 smartphone platform by market share from 1996 until 2011.

- Windows

- Microsoft Windows CE (now officially known as Windows Embedded Compact & previously also known as Windows Embedded CE, sometimes abbreviated WinCE) is an OS developed by Microsoft for embedded systems. Windows CE is a distinct OS of Kernel, rather than trimmed down version of desktop windows.
- Microsoft licenses Windows CE to OEMs & device makers. The OEMs & device makers can modify & create their own user interfaces & experiences, with Windows CE providing the technical foundation to do so.
- The current version of WinCE supports Intel x86 & compatibles, MIPS, & ARM processors.

- Palm OS

- Palm OS (also known as Garnet OS) is a mobile OS initially developed by Palm Inc. for PDA in 1996. Palm OS is designed for ease of use with a touchscreen-based GUI.
- It is provided with a suite of basic appl's for personal info. management. Later versions OS have been extended to support smartphones.

→ Palm OS is a proprietary mobile OS. Designed in 1996 for palm computing, new Pilot PDA, it had been implemented on a wide array of mobile devices, including smartphones, new pilot wrist watches, handheld gaming consoles, barcode readers & GPS devices.

→ Key features are:

- # Support of screen resolution upto 480x320 pixel
- # HotSync technology for data sync. with desktop computer
- # Sound playback & record capabilities
- # TCP/IP n/w access
- # serial port /USB, infrared, Bluetooth & Wi-Fi connections
- # Expansion memory card support
- # Handwriting recognition technology input system called Graffiti 2.

→ BlackBerry

- BlackBerry is a line of phone devices developed & designed by Research In Motion (RIM). The first BlackBerry smartphone was released in 1999.
- BlackBerry devices are smartphones, which are designed to function as PDAs, portable media players, internet browsers, gaming devices, cameras & much more.
- They are primarily known for their ability to send & receive push email & instant msgs while maintaining a high level of security through on-device msg encryption.
- BlackBerry devices support a large variety of instant messaging features, with the most popular being the proprietary BlackBerry Messenger Service.
- Modern GSM-based BlackBerry handsets incorporate an ARM 7, 9 or ARM 11 processor. All BlackBerry smartphones after OS 5 support upto 32 GB microSD cards.

→ iOS

- iOS (previously iPhone OS) is a mobile OS developed & distributed by Apple Inc. Originally released in 2007 for iPhone & iPod Touch, it has been extended to support other Apple devices such as the iPad & Apple TV.
- Apple does not license iOS for installation on non-Apple h/w. As of 2012 Apple's App Store contained more than 700,000 iOS apps, which have collectively been downloaded more than 30 billion times.
- The UI of iOS is based on concept of direct manipulation, using multi-touch gestures. Interface control elements consists of sliders, switches, & buttons. The response to user I/P is immediate & provide fluid interface. Interaction with the OS includes gestures such as swipe, tap, pinch & reverse pinch.
- iOS is derived from OS X, with which it shares the Darwin foundation, and is therefore a Unix OS. iOS is Apple's mobile version of OS X used on Apple computers.
- In iOS, there are four abstraction layers: the core OS layer, the core services layer, the media layer, & the Cocoa Touch layer.

- Android

- Android is a Linux-based OS designed primarily for touchscreen mobile devices such as smartphones & tablet computers, developed by Google in conjunction with the Open Handset Alliance.
- Initially developed by Android Inc., whom Google financially backed & later purchased in 2005, Android was unveiled in 2007 along with the founding of Open Handset Alliance, a consortium of 86 h/w, sw, & telecom. companies devoted to advancing open standards for mobile devices.
- The Android Open Source Project (AOSP), lead with Google, is tasked with maintenance & further development of Android.
- Additionally, Android has a large community of developers writing apps that extend the functionality of devices. Developers write primarily in a customized version of Java & apps can be downloaded from online stores such as Google Play (formerly Android Market), the app store run by Google, or third-party sites.
- The 1st Android-powered phone was sold in October 2008, & by end of 2010 Android had become world's leading smartphone platform (59% market share at beginning of 2011)

- Bada

- Bada is an OS for mobile devices such as smartphones & tablet computers. It is developed by Samsung Electronics. All Bada-powered are branded under the Wave name.
- Bada is not an OS itself but a platform with a kernel configurable architecture, which allows using either a proprietary real-time OS hybrid (RTOS) kernel or Linux kernel.
- In architecture of Bada the device layer provides core func's such as graphics, protocols, telephony & security. The service layer provides more service centric features such as SMS, mapping & in-app purchasing. To provide such features there is a so-called Bada Server. The top layer, the framework layer provides an API in C++ for appn developers to use.
- Bada supports many mechanisms to enhance interaction, which can be incorporated into appn's. These include various sensors such as motion sensing, vibration control, face detection, accelerometer, magnetometer, tilt, GPS, & multi-touch.
- Native appn's are developed in C++ with Bada SDK, & the Eclipse based IDE.

* Mobile Agents (MA)

- In computer science, a MA is a composition of computer sw & data which is able to migrate (move) from one computer to another autonomously & continue its execution on the dest. computer. In reality, the MA is the code/object on move which travels in its itinerary within the n/w of connected devices/nodes.
- Advantages of Mobile Agents:
 - (i) Reduction of N/w Traffic
 - (ii) Overcome n/w latency

- (vi) Encapsulation of Protocols
- (v) Dynamic Adoption
- (vi) Robust & Fault-Tolerance
- (ix) Personal Assistance
- (xi) Distributed Info. Retrieval
- (xii) Workflow Apps & Groupware
- (xv) Info. Dissemination

- (iv) Asynchronous & Autonomous Execution
- (vi) Seamless system integration
- (viii) Electronic Commerce
- (x) Secure Brokering
- (xii) Telecom. N/w services
- (xiv) Monitoring & Notification
- (xvi) Parallel Processing

- Configuration of MA:

- Simple Reflex Agent: In this case, agent does not have memory. It simply perceives the current situation, finds a rule that matches the situation & executes it.
- A Reflex Agent with Internal State: Agent perceives the current situation and based on its perception & stored internal state finds a rule that matches the situation & executes it.
- An Agent with Explicit Goals: Agent selects those actions that help it achieve goals. Compared to simple reflex agent, it is more flexible.
- An Utility-based Agent: While achieving its goal, this agent also maximizes some performance measure.

- Architectures of MA:

- Single Agent System
- Multi-Agent Systems
- ~~Homogeneous Non-communicating Multi-agent Sys~~
- Multi-Agent System forms:
 - Homogeneous Non-Communicating
 - Homogeneous Heterogeneous Non-Communicating
 - Heterogeneous Communicating
- Challenges in Implementing MA(s)
 - Protection of Host from Malicious agents
 - Protect of Agents from Malicious agents
 - Portability & Standardization
 - Performance & Scalability

* Introduction To Mobile Appln Languages & Tool Kite

- Mobile App Development Languages

- i) Java
- ii) Javascript
- iii) Objective-C : It is a C-language superset & has a lot of funcs which mainly deal with graphics, display funcs & I/O.
- iv) Swift: (for Apple Devices)
- v) PHP
- vi) Python

(vii) HTML5

(viii) C#: It is an expansion of C that directly addresses many of the unique features of the environment of default (or recommended) programming language for window-based apps.

(ix) C++

(x) C

(xi) SQL

- Tools

(i) Sencha Touch:

- It is an open source cross-platform mobile app development tool written in Javascript.
- It supports development on all platforms like Android, iOS, BlackBerry, Kindle, Windows Phone & Tizen.
- It is a user interface Javascript library or framework built specially for mobile web.
- Its features are listed below:
 - # Faster Layouts
 - # Cordova support
 - # HTML5 device APIs
 - # Native Packaging

(ii) Apache Cordova / PhoneGap:

- Apache Cordova (formerly known as PhoneGap) is an open source mobile app development framework originally created by Nitobi. After Nitobi was bought by Adobe Systems, the company redesigned PhoneGap & released the same as Apache Cordova, which allows developers to use web technologies like HTML5, CSS3 & Javascript for cross-platform development.
- The unique features are:
 - # Cordova is regarded as Javascript API acting as a wrapper for native code & is consistent across devices. It is regarded as an app container with a web view, which covers the entire screen of device.
 - # Cordova is bundled with predeveloped plugins to support access to phone's camera, GPS & file system.
 - # Cordova installs just like native apps. It will produce an IPA file for iOS, apk file for android & XAP file for windows phone.

(iii) Appcelerator Titanium:

- It is an open source mobile app development framework for iOS, Android & Windows Phone from a single Javascript code base.
- Its features are:
 - # Provides Javascript based ~~SDK~~ with other 5000 APIs for Android, iOS, Windows, BlackBerry & HTML5.

- # Developers can make use of their web development skills to build rich & fancy native apps for almost any mobile platform.
- # Reuse 60-90% of code when supporting multiple platforms.
- # Has a cross platform API for accessing native UI components & native device functionality

(iv) QT :

- It is an important cross-platform mobile app framework mostly used for developing app UIs that can run on various SW & HW platforms with little or no change in the underlying code base.
- It is mainly used for developing various app UIs with or without GUI interface.
- QT chiefly uses C++ with signal & slot extensions, which make it easy when handling events & helps in developing the GUI of server apps.
- It supports many compilers like G++ & even Microsoft Visual Studio.
- Its features are:

QT Core # QT Widgets # QT QML # QT Bluetooth
QT Web Engine # QT GUI # QT Webkit

(v) Xamarin SDK :

- Xamarin has created a robust cross-platform mobile app development platform that has been adopted by various IT tech giants like Microsoft, Foursquare, IBM etc. using Ruby or C#.
 - With the C# shared code base, developers use Xamarin tools to write native Android, iOS & Windows apps with native UI & shared code across multiple platforms.
 - Xamarin offers two commercial products: Xamarin.iOS & Xamarin.Android. Both are built on top of Mono, an open source version of the .NET framework & can run on various platforms like Linux, Unix, Free BSD & Mac OS X.
 - Its features are:
- # Objective-C, Java, C & C++ Interop
Modern language constructs
Binding for SDKs
Cross-Platform support.