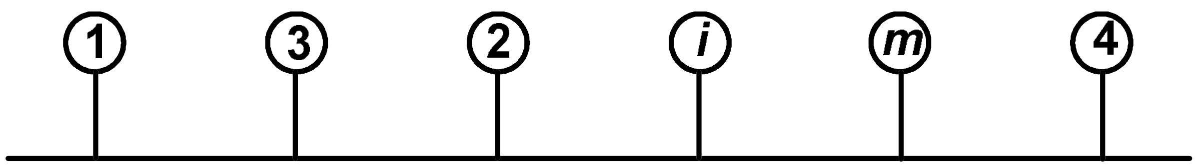
Token Bus

Conceptually, a taken bus is the same as a token ring.

When one node finishes transmission, it sends an idle token to the next node.

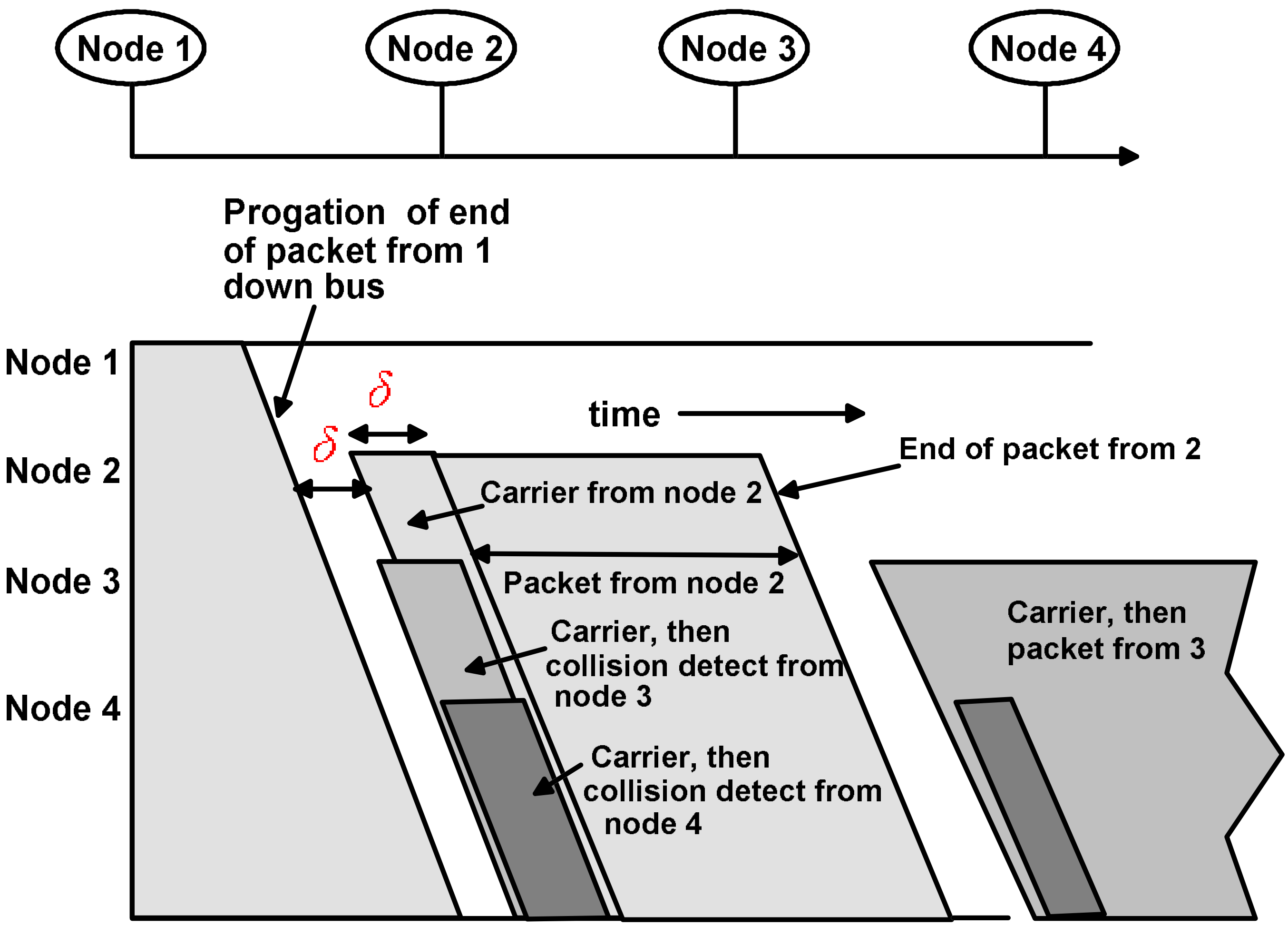
With a token bus, the next node can be arbitrary, so the token contains an address. Thus flexibility is gained at the cost of efficiency.



A polling system is quite similar to a token bus; instead of a node sending the token to the next node, it notifies master node that it is finished and the master node notifies the next node.

CSMA/CA: the idle tokens on a token bus can be replaced by silence.
The next node starts transmission after hearing the bus silent. If the next node has no packet, successive nodes start with successive silence delay (“ implicit token”)

e.g. Expressnet Unidirectional Buses (usually optical fiber)



For unidirectional buses, combining implicit tokens, carrier detection and bus ordering (to resolve conditions) gives an interesting system.

Downstream nodes hears the collision and stops transmitting.

Each node with traffic transmits carrier on hearing silence; then defers to upstream nodes on hearing carrier.

Unfair to downstream node.

Logarithmic Search

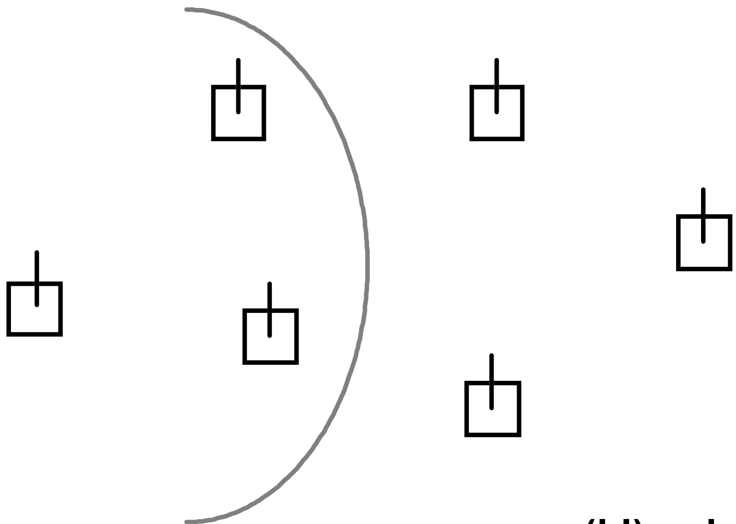
Under light loading it is time consuming to poll (or pass a token, or use TDM to make a reservation); it is preferable to do a logarithmic search.

Nodes								Output	
0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1	y	
0	0	1	1	0	0	1	0	1	Slot 1
0	0	1	1	0	0	0	0	1	Slot 2
0	0	0	0	0	0	0	0	0	Slot 3
0	0	1	0	0	0	0	0	1	Slot 4

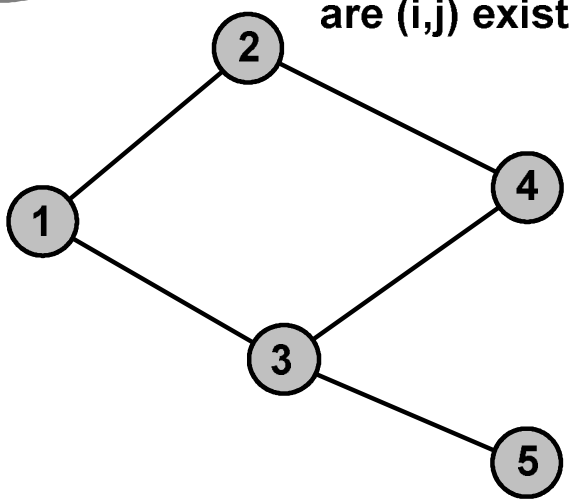
Nodes are numbered in binary.
In the first slot, all nodes with a packet send 1
If the output is 1, all nodes whose most significant digit is 0, and which have a packet, send 1, etc..

The logarithmic search strategy finds the lowest numbered node with a packet in at most $\lceil \log_2 m \rceil$+1 steps. This is preferable to ordinary polling for light loading, but worse at heavy loading.
Fairness problem (solution: change node's binary id at end of cycle)

Packet Radio Networks



are (i,j) exist if j can hear i



Collision free set: set of links that can carry packets simultaneously with no collision at receiving ends of the links.

Collision free vector (CFV)

(1, 2)	(2, 1)	(1, 3)	(3, 1)	(2, 4)	(4, 2)	(3, 4)	(4, 3)	(3, 5)	(5, 3)
1	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	1	0	0
0	1	0	0	0	0	0	0	0	1

TDM for Packet Radio Networks

$\overline{x_1}, \overline{x_2}, \cdots, \overline{x_J} \in \{0,1\}^L$: **collision-free vectors**

L**= # links**

- **Give each collision free set one slot.**

$\overline{f} = \dfrac{\sum_{j=1}^{J} \overline{x}_j}{J}$ =**vector that gives fraction of time each link is used.**

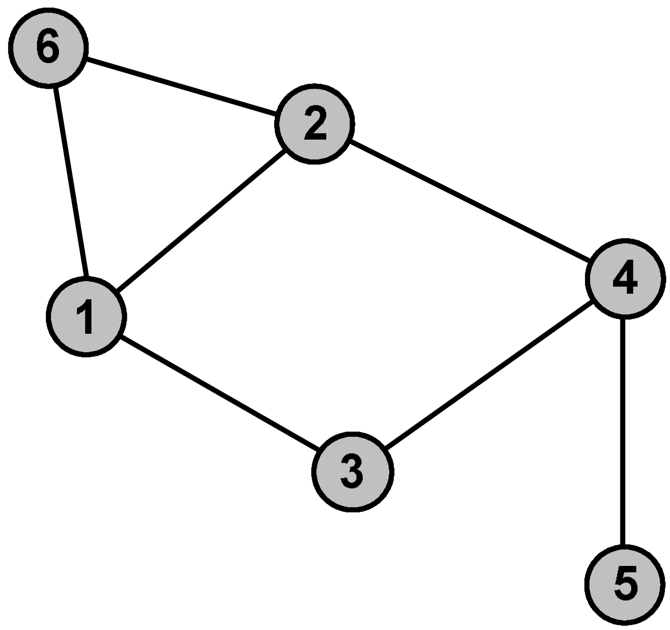
$\overline{f}$ =**utilization vector**

- **More generally: let a_j be the fraction of time the j th collision free set is used, where** $\sum_{j=1}^{J} a_j = 1.$

$\overline{f}(\overline{a}) = \sum_{j=1}^{J} a_j \overline{x}_j$**= vector that gives fraction of time each link is used**

- **Given $\overline{f}_{desired}$ find a_j 's so that** $f(\overline{a}) = \overline{f}_{desired}$, $\sum_{j=1}^{J} a_j \leq 1.$
- **Different when collision free sets change (actually, even for a static net, it is NP-complete.**

Collision Resolution Schemes for Packet Radio



e.g. Slotted Aloha

Problem is unreliable feedback

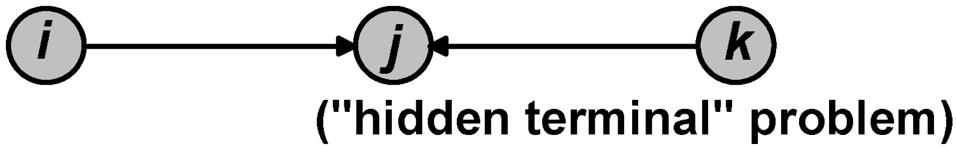
Ex.1: 1 → 2 and 4 → 5 ⇒**collision at 2 (but 1 does not know it)**

Ex.1: 6 → 1 and 4 → 5 ⇒**both transmissions are successful but there is a collision at 2 who does not know if transmission was intended for him.**

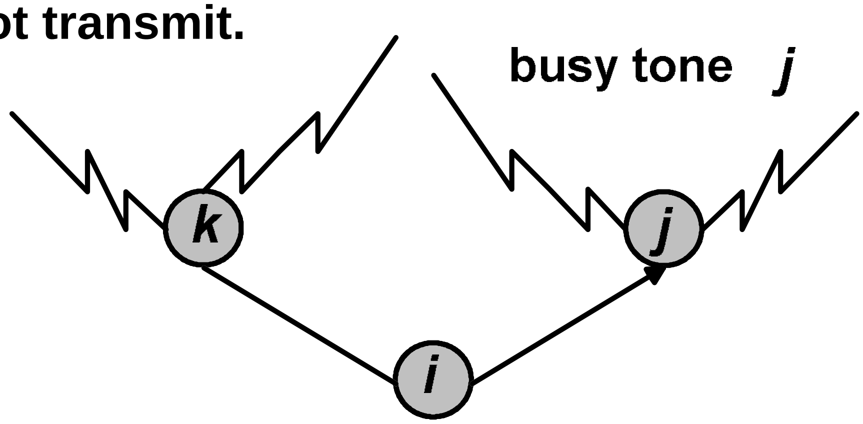
Solution: explicit ACK's have to be sent.

Carrier Sensing and Busy Tones for Packet Radio Nets

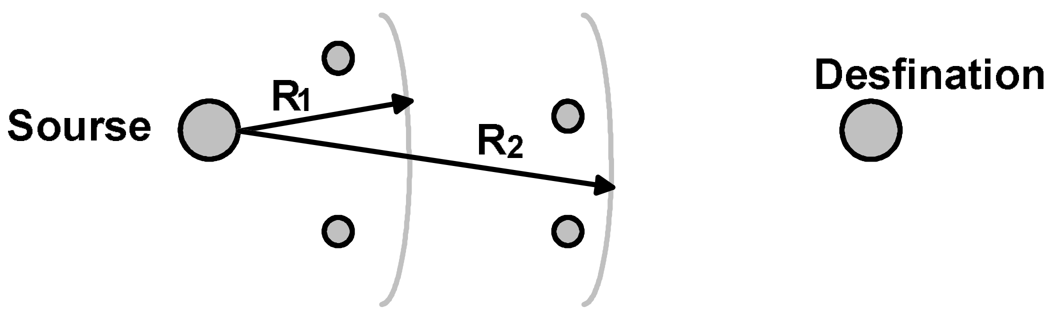
Carrier Sensing does not always work: *i* is transmitting to j; k detects the channel idle and transmit ⇒ collision



Busy tones: a node which is receiving transmit a busy tones at another frequency; nodes that listen the busy tone do not transmit.

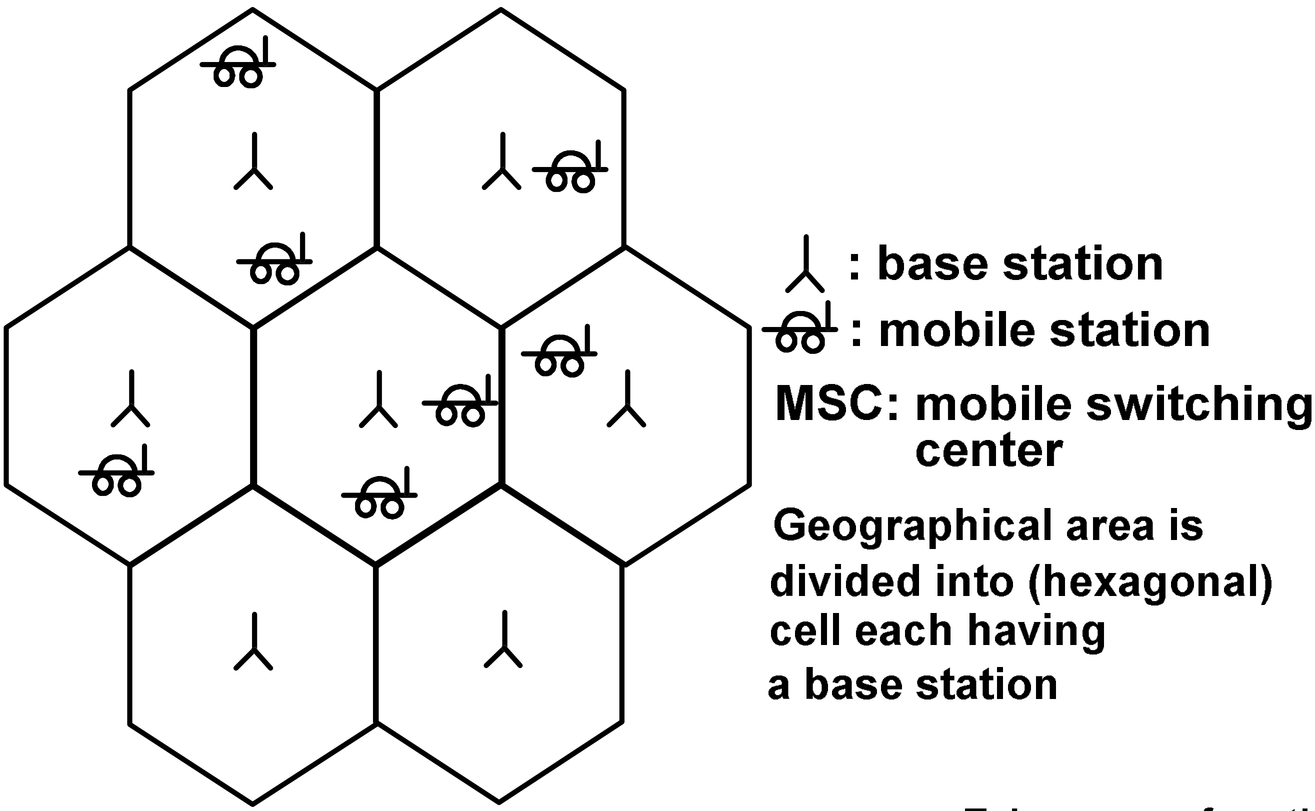


Another issue: choice of the transmission radius.

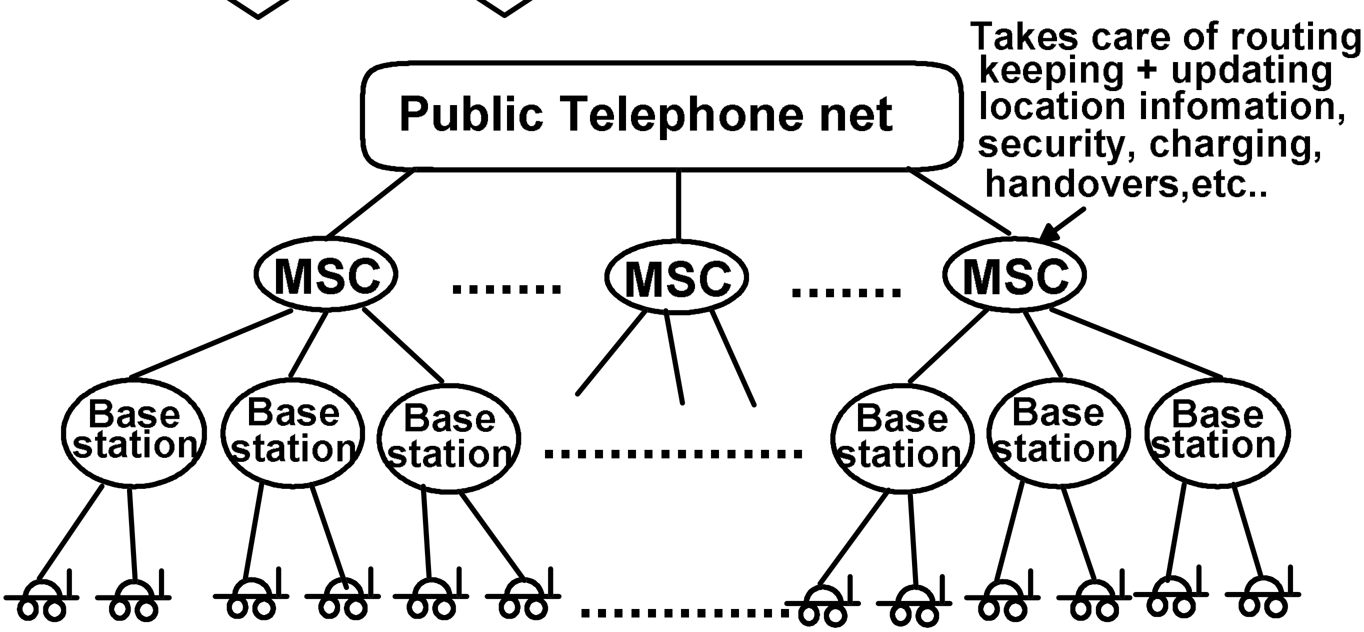


If a large transmission radius is used, it takes fewer hops to get to the destination, but causes more interference to other users.

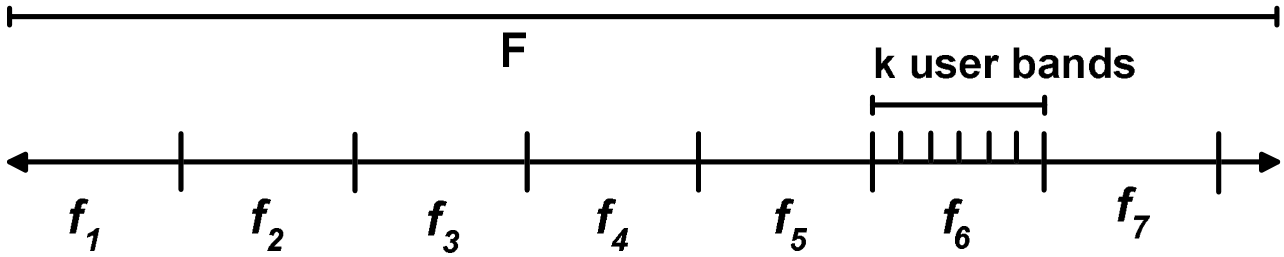
Cellular Telephone



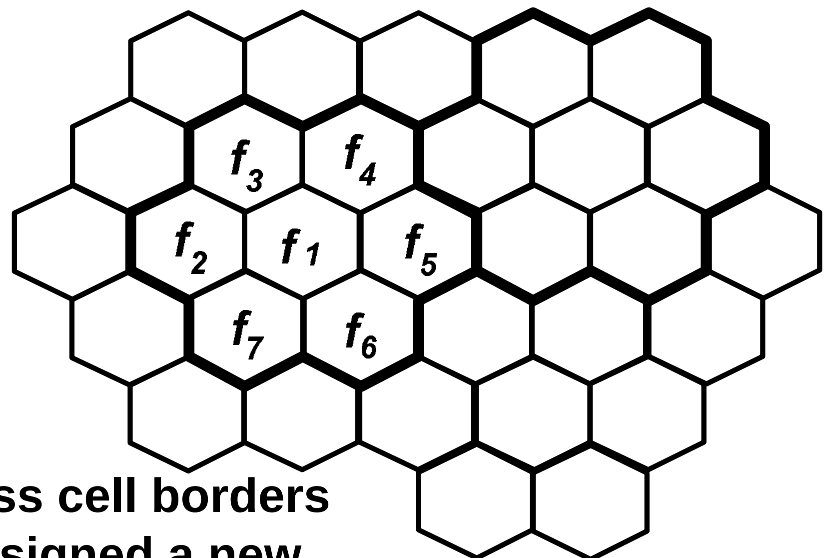
Geographical area is divided into (hexagonal) cell each having a base station



Cells that are close to each other cannot use same frequencies due to potential interference to each other.



Each cell is given a frequency band (each band can serve a number of mobiles). Only cells that are at 3 or greater can be given the same band.



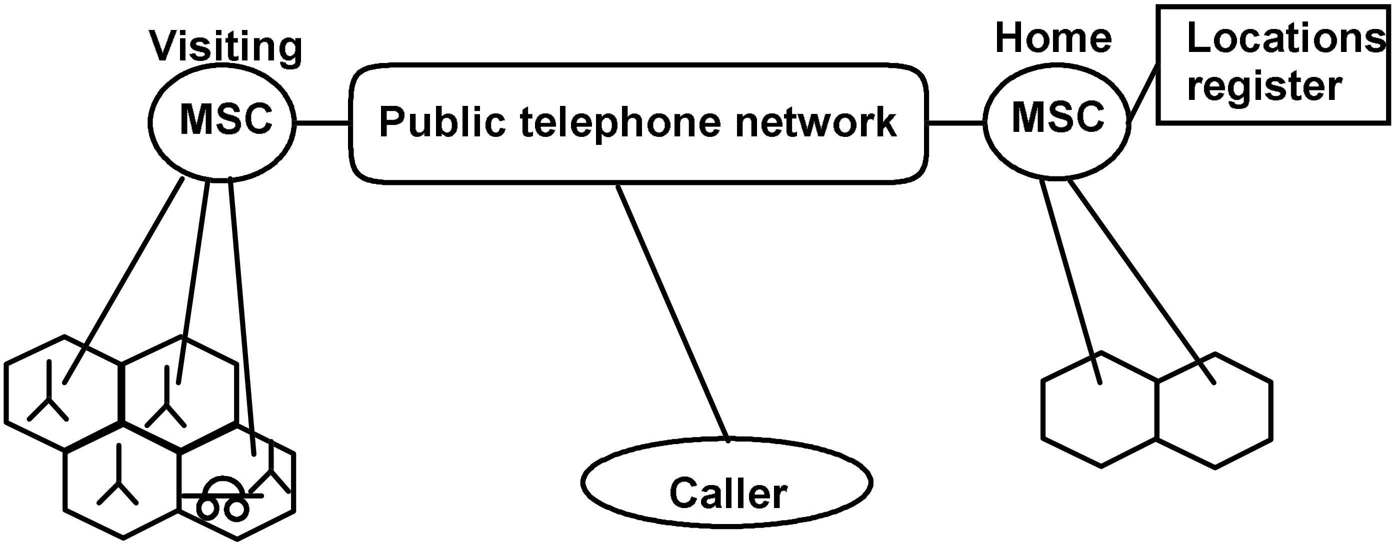
<u>Advantage:</u>
frequency reuse (without excessive interference from other cells)

<u>Disadvantages:</u>

a) when mobiles cross cell borders they have to be assigned a new frequency (handover)

b) if the distribution of the mobiles into the cells is unbalanced then inefficient bandwidth utilization (then we can do better by having a dynamic allocation of frequencies to cells, as opposed to a fixed allocation)

Location updates & call routing



Mobile is registered at a particular MSC (home).

when mobiles moves to areas other than his home area, a register in the home MSC storing the current location of the mobile is updated.

Caller rings the home MSC, the location register is read and then call is forwarded to the appropriate MSC and from these to the visiting BS.