Vertical Handoffs in Wireless Overlay Networks

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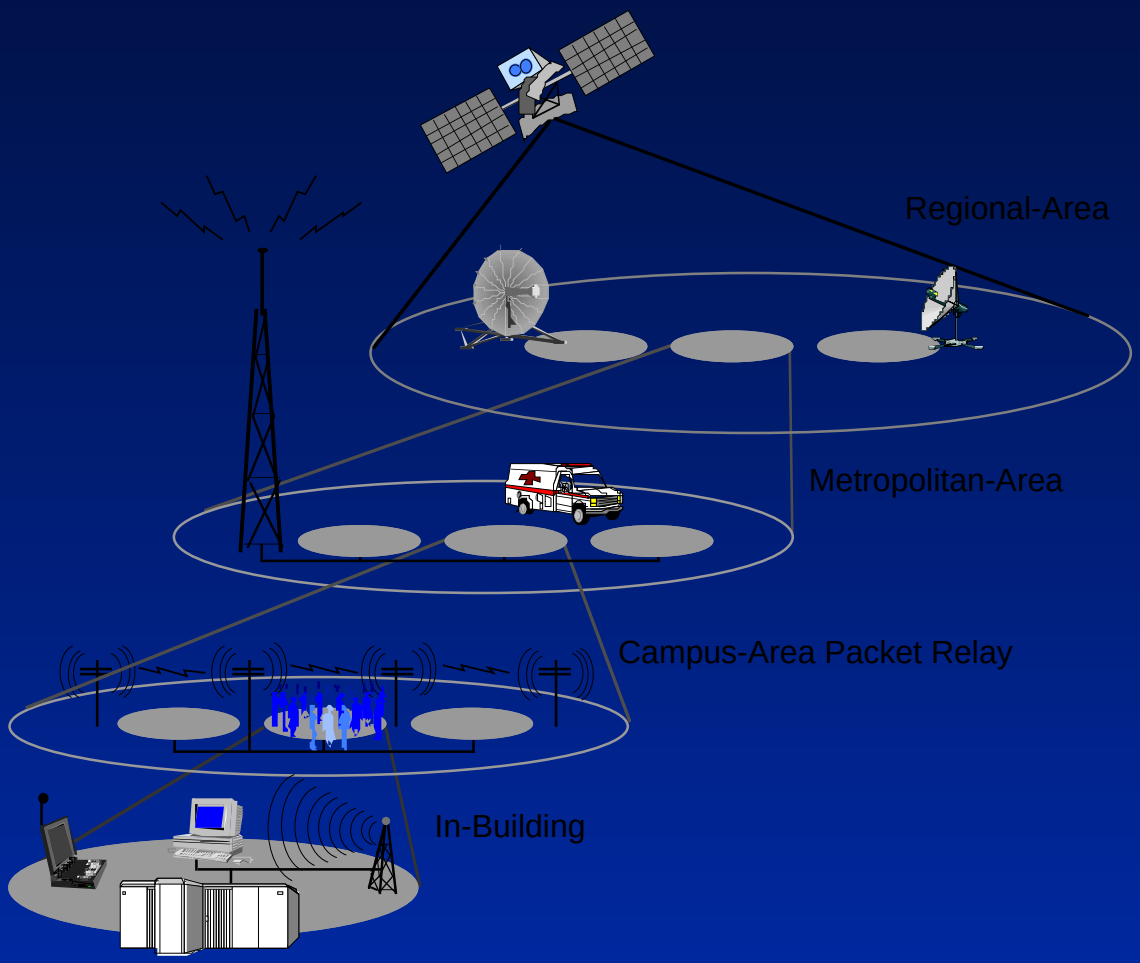
Wireless Overlay Structure



- *Horizontal Handoffs* within an overlay.
- *Vertical Handoffs* between overlays.
- *Upward handoffs* to overlay with larger cell size.
- *Downward handoffs* to overlay with smaller cell size.

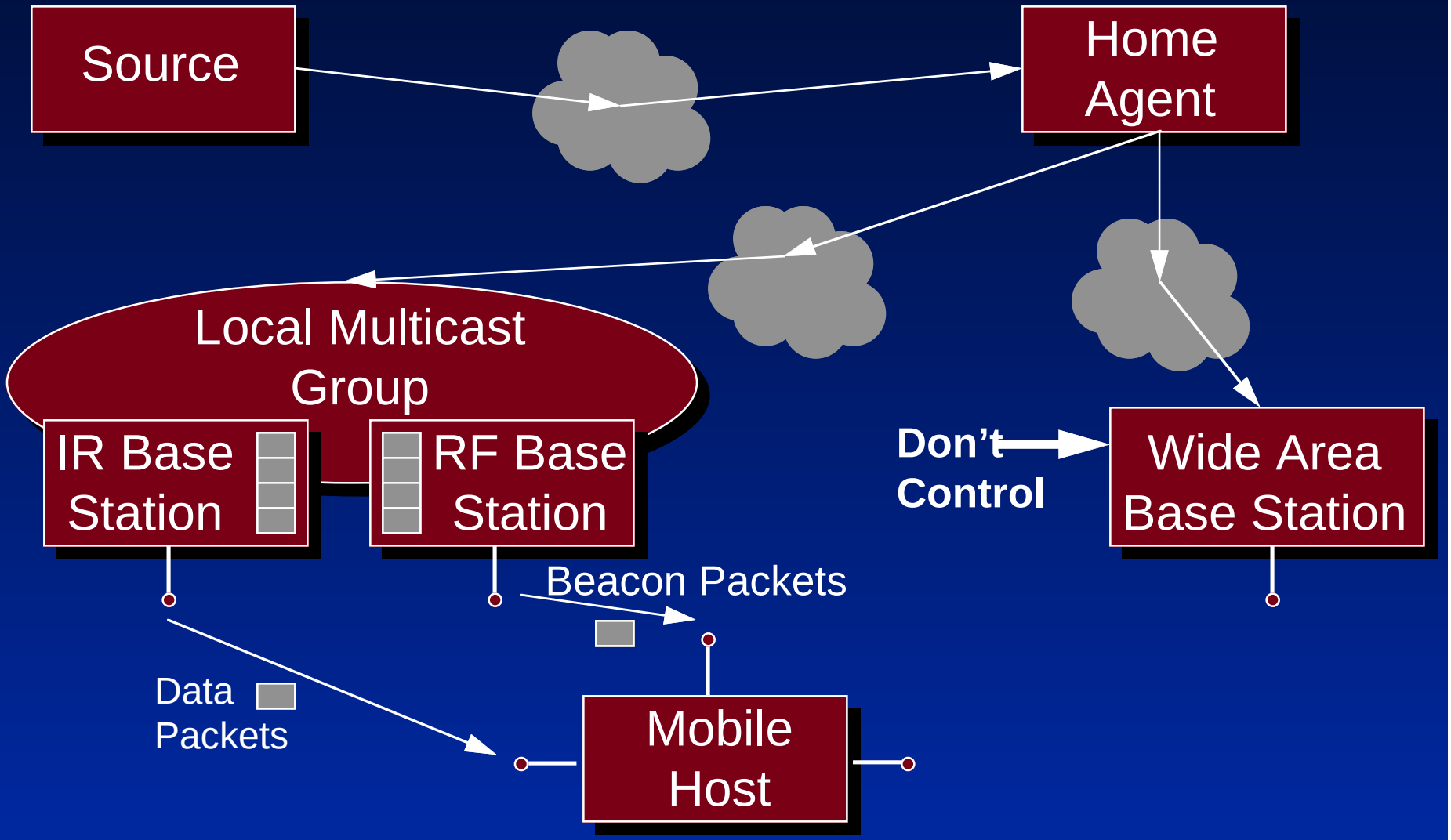
Differences in Vertical Handoffs

- "Interface diversity"
  - Can send data over multiple NIs at once
- In range of multiple BSs all the time
  - Due to overlapping nature of cells
- The choice of the "best BS" is not obvious
  - Hard to compare signal strength of IR, RF
  - Our heuristic: *stay in the lowest overlay possible for as long as possible*

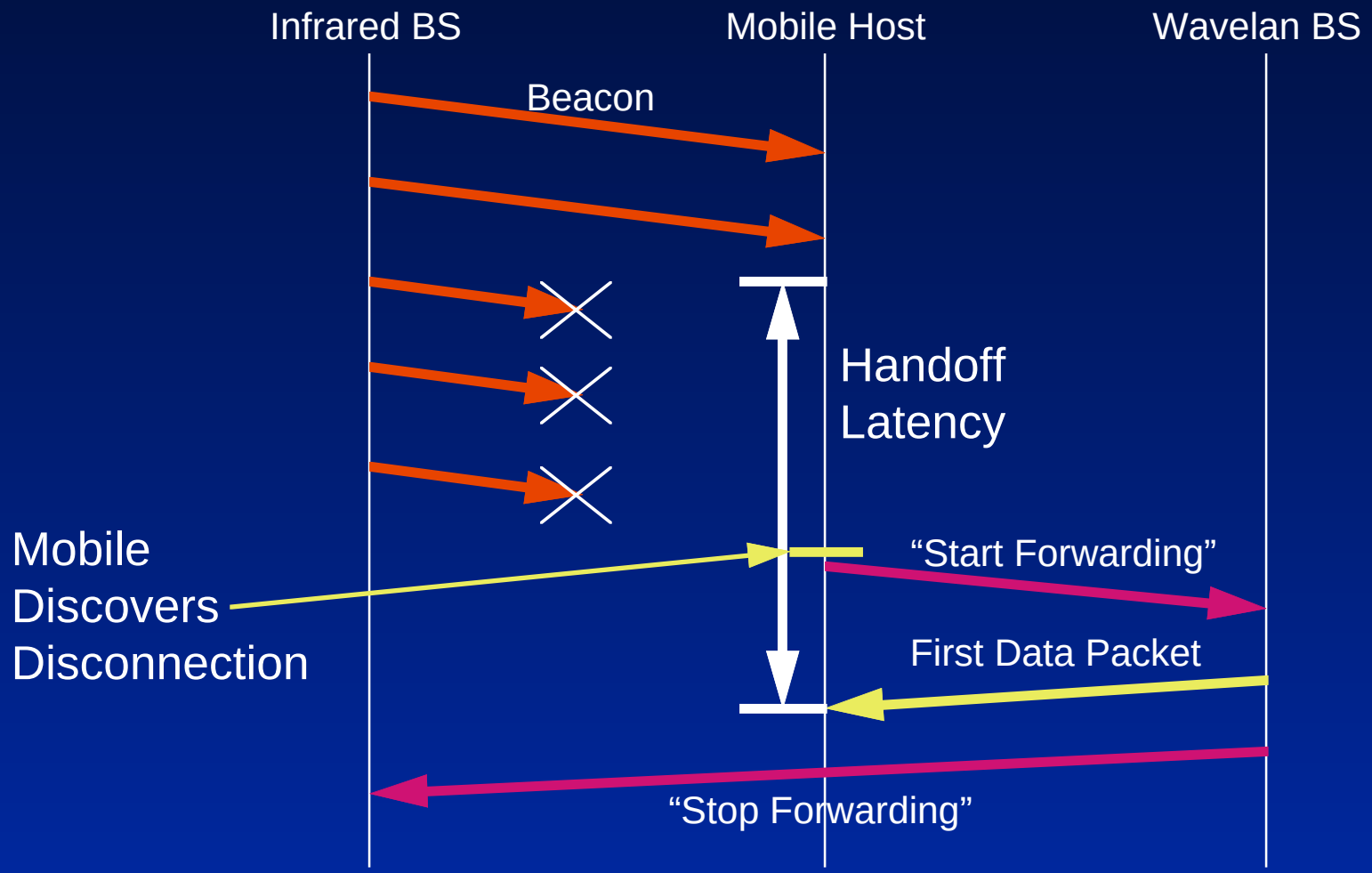
Challenges

- Low latency
- Minimize power drain
- Minimize bandwidth overhead
- Discover the “right” time to hand off in a wireless channel that is hard to characterize
- Work with commercially available devices:
  - No hardware carrier tone
  - Can’t control the infrastructure

Basic System Overview



Basic System Handoff (Upward)



Metrics

- Handoff Latency=Ld+Lp+Ln+Lf
  - Ld=Time to *discover* that overlay is gone
  - Lp=Time to *power* on new NI
  - Ln=Time to *notify* new base station to forward
  - Lf=Time for new BS to *forward* 1st packet to MH
- Bandwidth Overhead
- Power Drain

Performance of Base System

- Handoff Latency
  - Ld=2.5 secs
  - Lp=100ms for IR–>WL, 6 sec for WL–>Metricom
  - Ln=5 ms for IR–>WL, 100ms for WL–>Metricom
  - Lf=8 ms for IR–>WL, 126ms for WL–>Metricom
  - Ld is everything!!
- Bandwidth Overhead
  - 1 beacon packet (64 bytes) per second
- Power Consumption
  - Lower interface only (350mW IR/1100 mW Wavelan)

Optimizations to Base System

- Reduces Ld with an increase in power or bandwidth overhead
- When to use them:
  - At user's request
  - Low received signal strength
  - Geographic hints
  - Increased handoff frequency

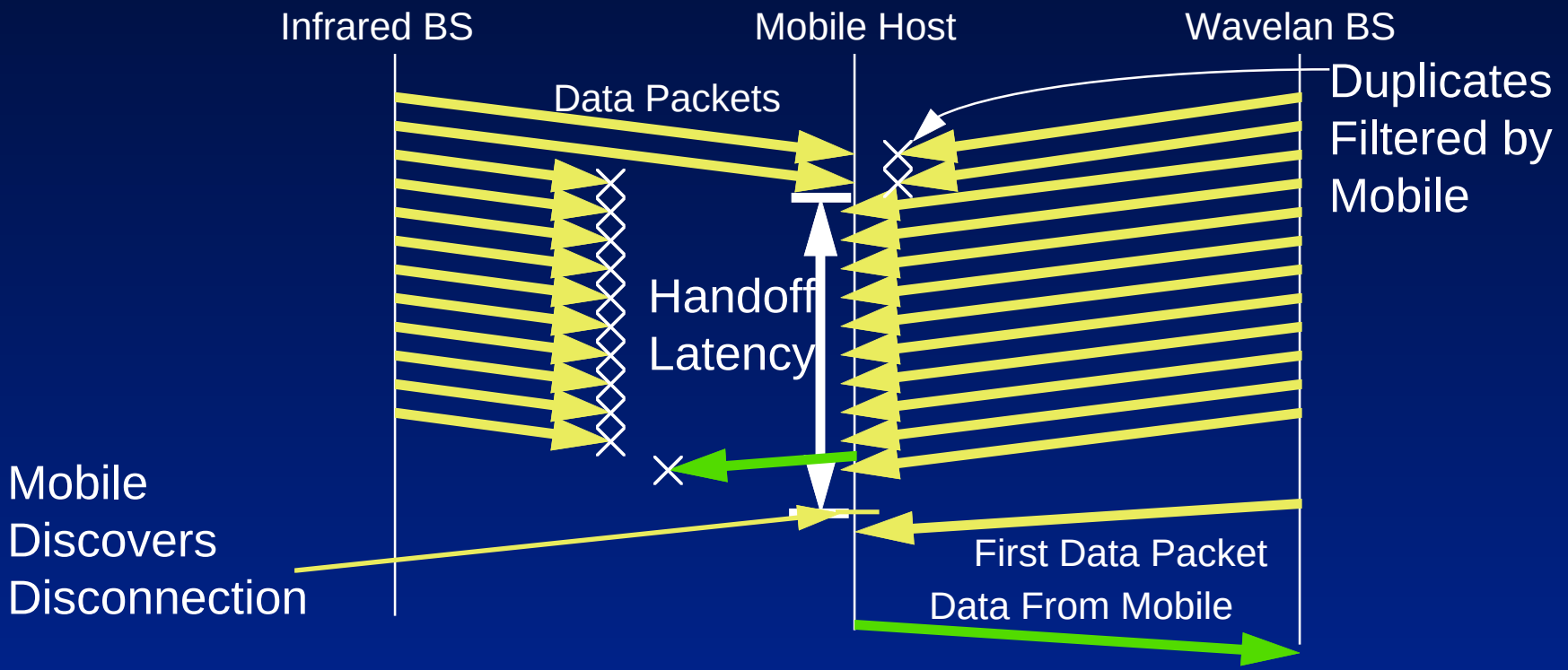
Optimizations(contd.)

- Fast Beaconing
  - Send beacons faster than once per second
- Packet Doublecasting
  - Send packets over both interfaces
  - Like “soft handoffs” in IS-95
- Header Doublecasting
  - Send packets over 1 interface and headers over other interface

Fast Beaconing Performance

- With a beacon spacing of 200ms...
- Handoff Latency
  - Ld=500ms
  - Lp, Ln, Lf same as basic system
- Bandwidth Overhead
  - 5 beacon packets (310 bytes) per second
- Power Drain
  - Same as basic system

Packet Doublecasting Handoff

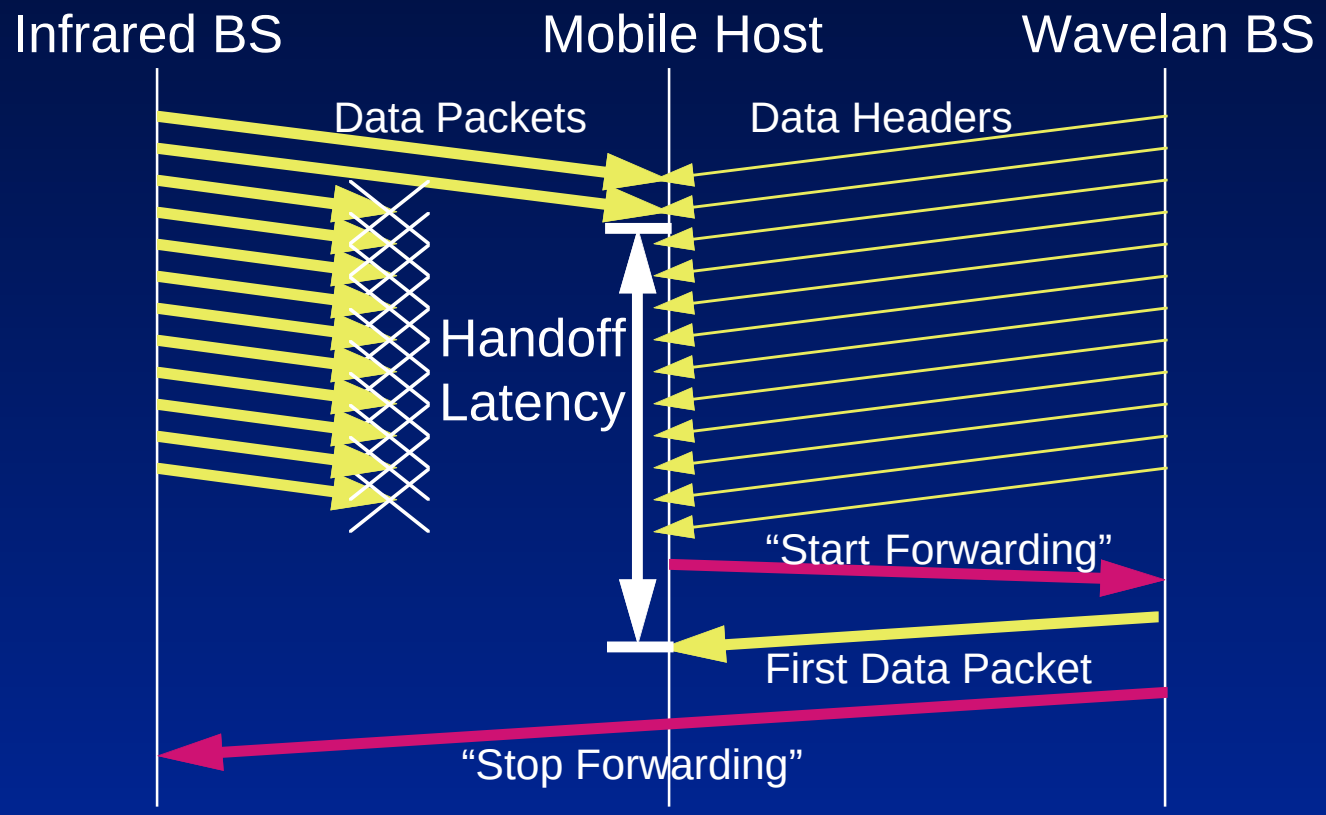


- Data to mobile is never lost during handoff
- Data from mobile is lost during handoff

Packet Doublecasting Performance

- Handoff Latency
  - Ld=200ms for IR–>WL, 1.5 sec for WL–>Metricom
  - Lp, Ln, Lf=0
- Bandwidth Overhead
  - Equal to data rate: 500 kbits/sec for IR–>WL, 50 kbits/sec for WL–>Metricom
- Power Drain
  - Both NIs must be on: 1450mW IR–>WL, 1450mW WL–>Metricom

Header Doublecasting Handoff



- Data to and from mobile is lost during handoff

Header Doublecasting Performance

- Handoff Latency
  - Ld=200ms for IR–>WL, 1.5 sec for WL–>Metricom (!!)
  - Lp=0
  - Ln=Same as Basic System
  - Lf=Same as Basic System
- Bandwidth Overhead
  - 16.6 kbits for IR–>WL, 1.66 kbits for WL–>Metricom
- Power Drain
  - Same as packet doublecasting

Summary

- Basic system has a high handoff latency due mostly to the “discovery time” Ld
- Fast beaconing decreases handoff latency with increased bandwidth overhead
- Packet doublecasting achieves low latency with least disruption at a considerable cost
- Header doublecasting achieves same handoff latency as packet doublecasting with a dramatically reduced cost
- Best Case=200-500ms with 1% overhead.