MAS.S66
Computational Wireless Sensing

Lecture 3 (part 2):

Seeing Through Walls

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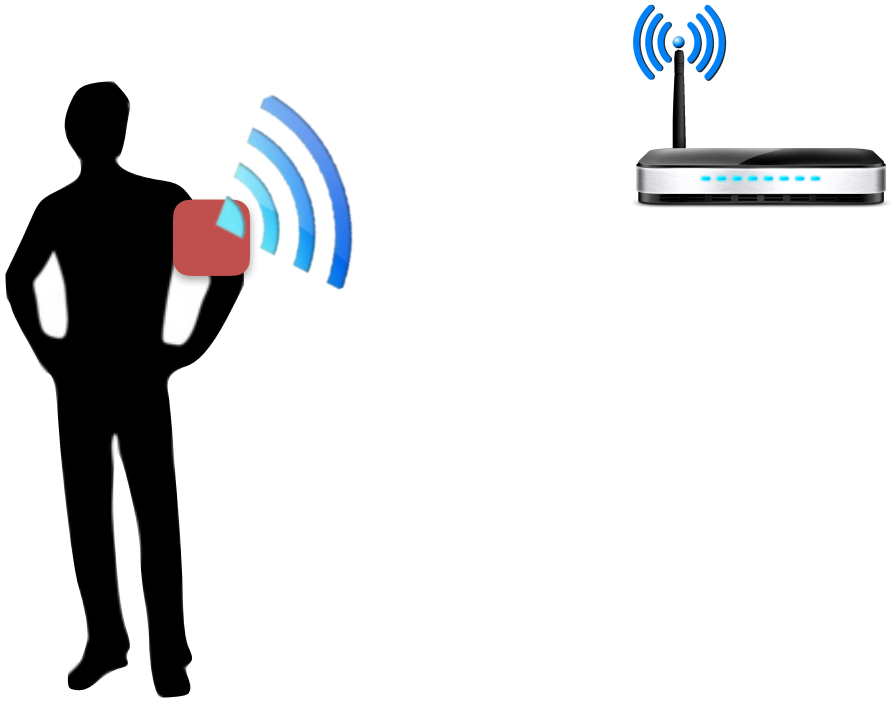
So Far: Device-based Localization



Next: Using radio signals to track humans without any sensors on their bodies

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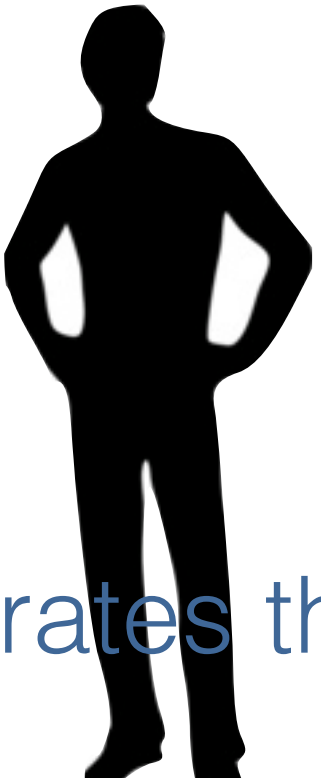
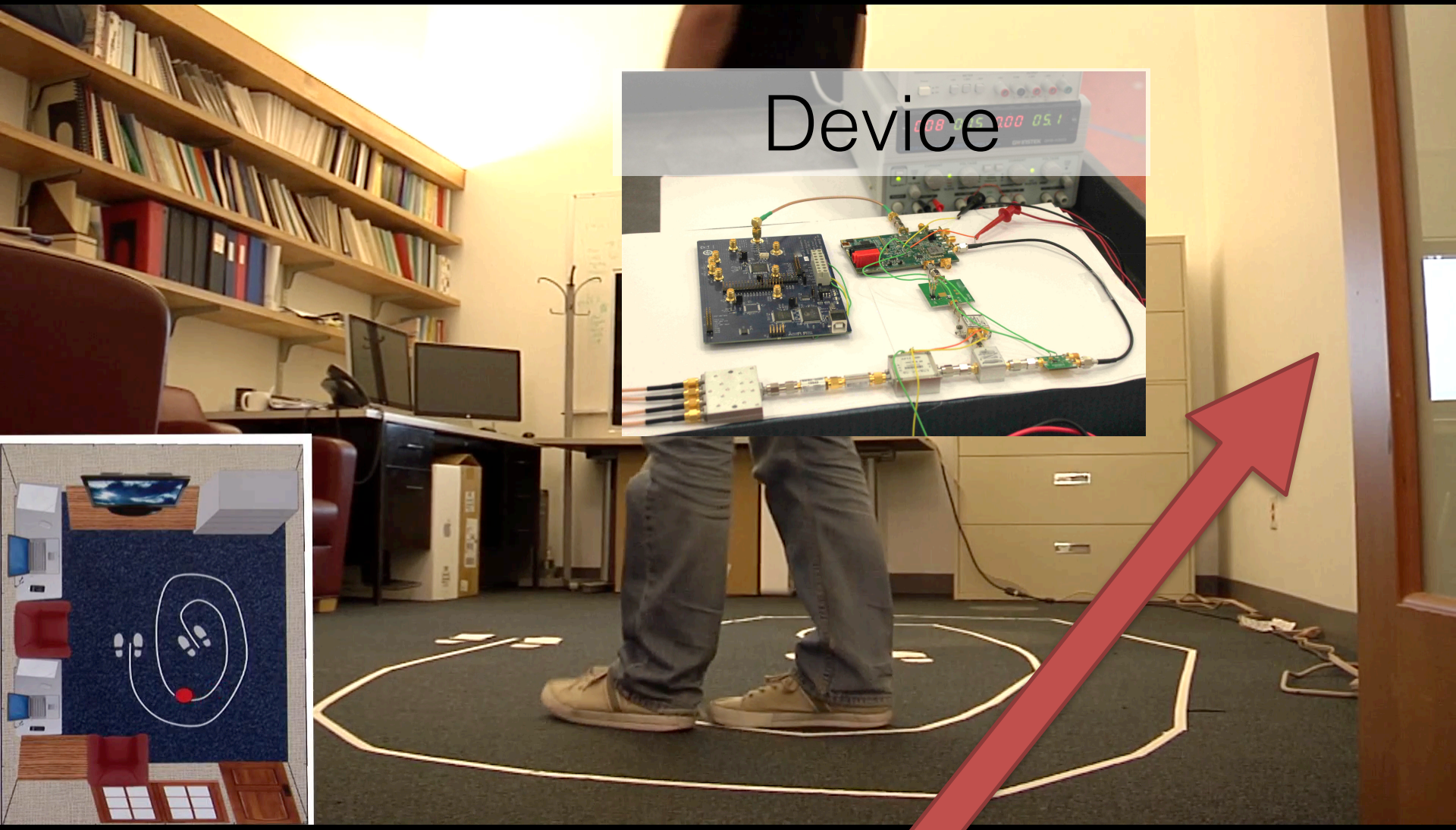


- Location
- Vital Signs
- Gestures

Operates through occlusions

Example: WiTrack


Device
Device in another room

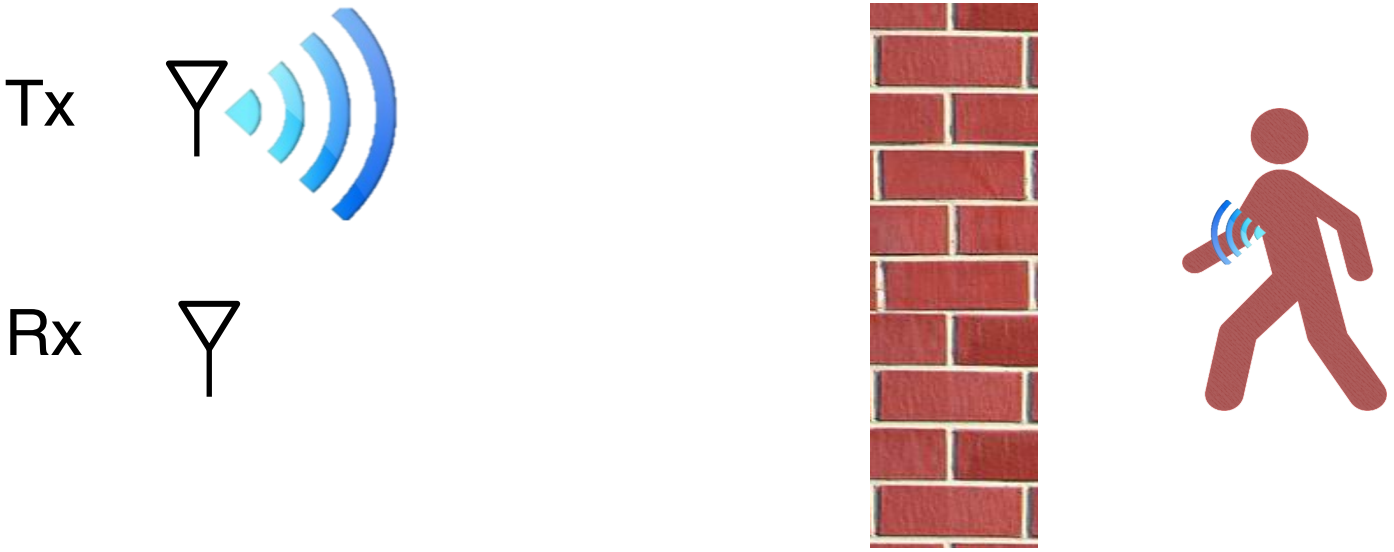
Applications

Smart Homes

Energy Saving

Gaming & Virtual Reality

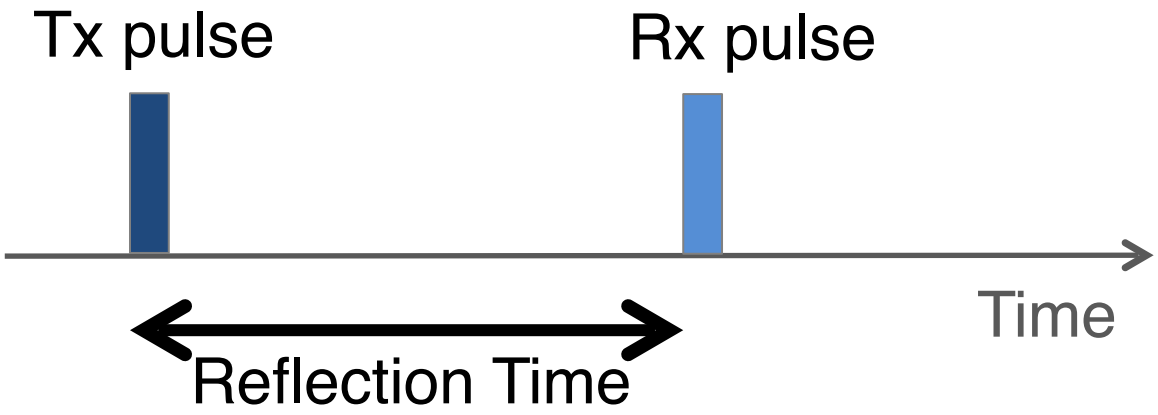
Measuring Distances



Distance = Reflection time x speed of light

Measuring Reflection Time

Option1: Transmit short pulse and listen for echo



Measuring Reflection Time

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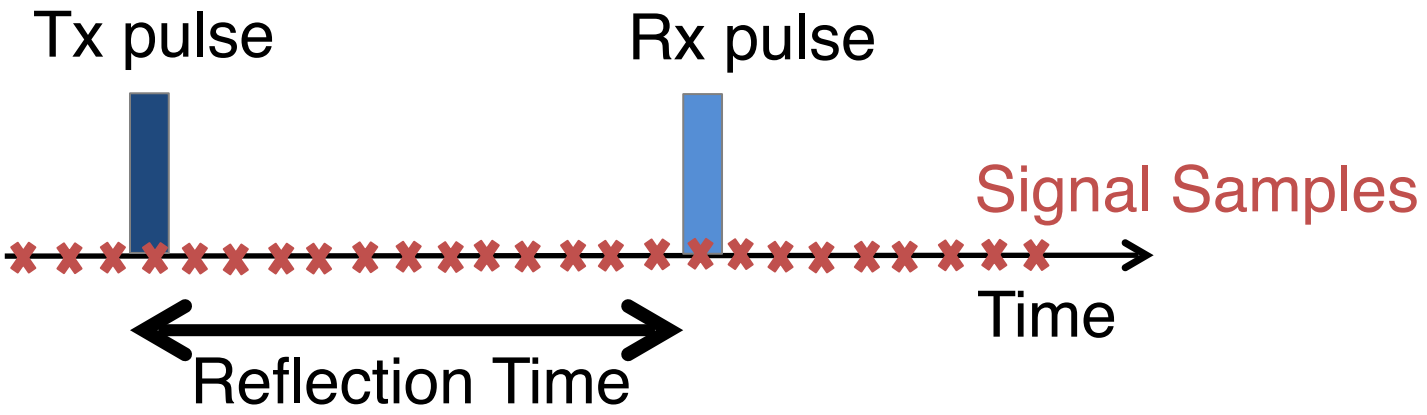
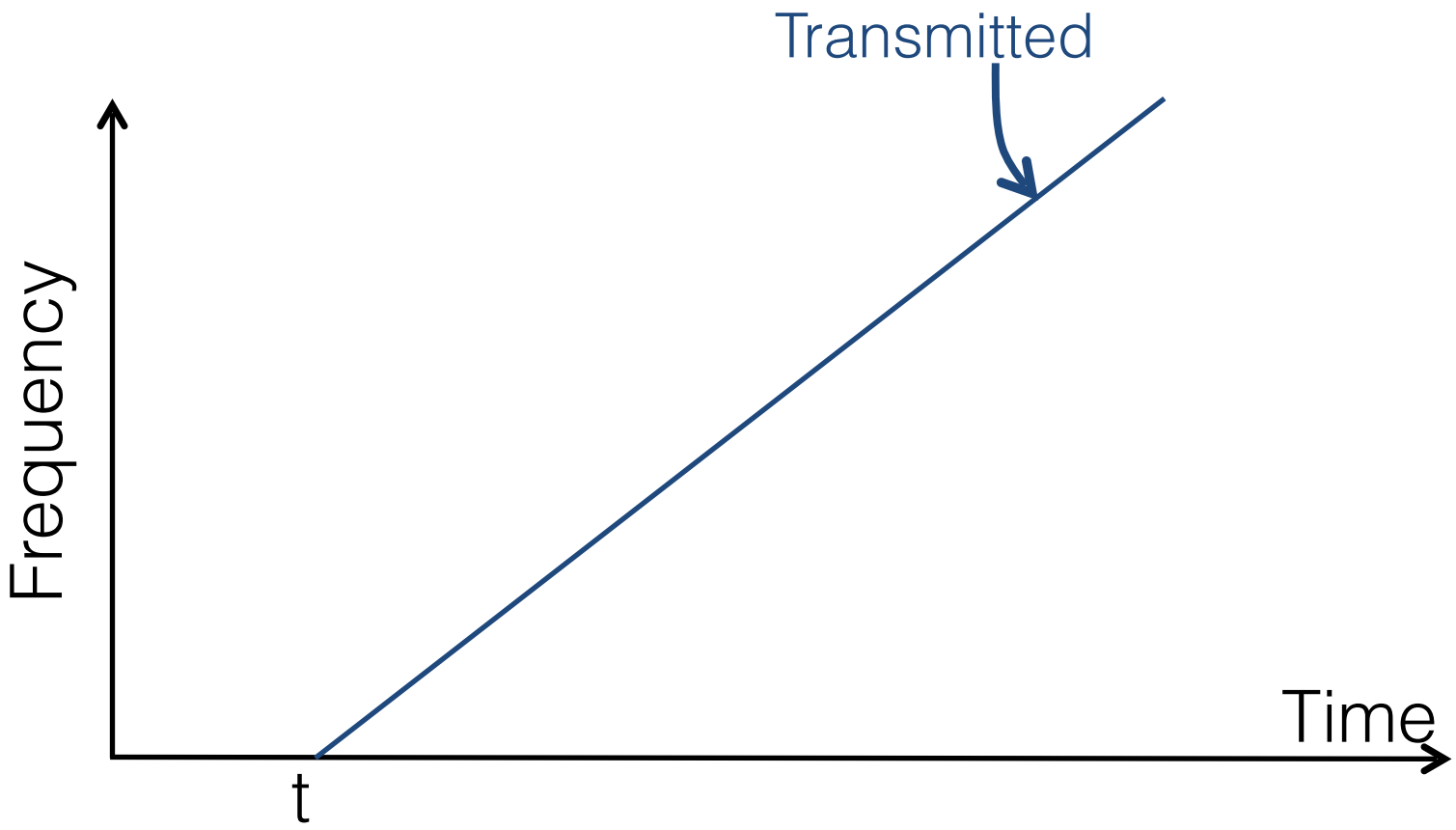


Capturing the pulse needs sub-nanosecond sampling

Why?

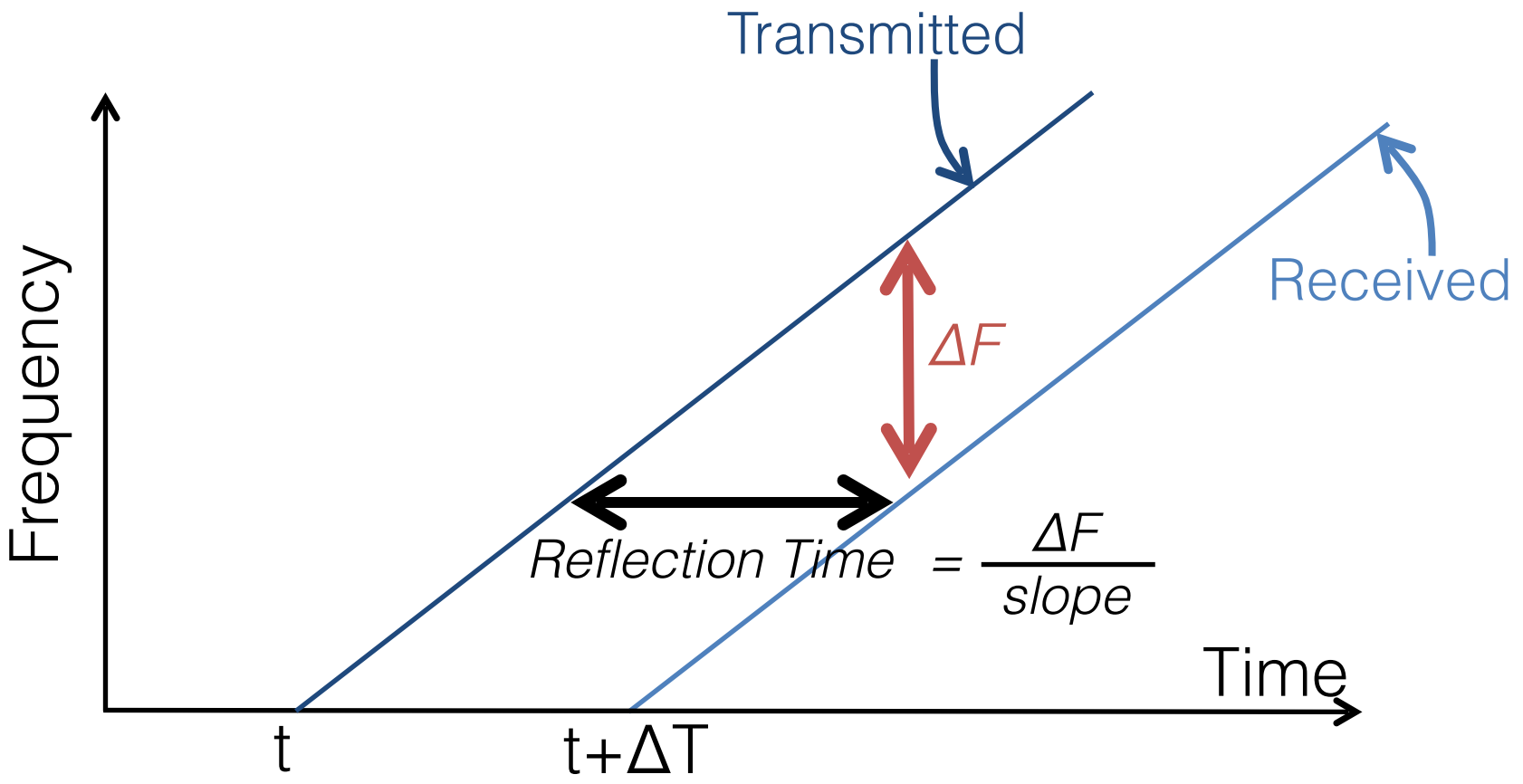
Why was this not a problem for Cricket?

FMCW: Measure time by measuring frequency



How does it look in time domain?

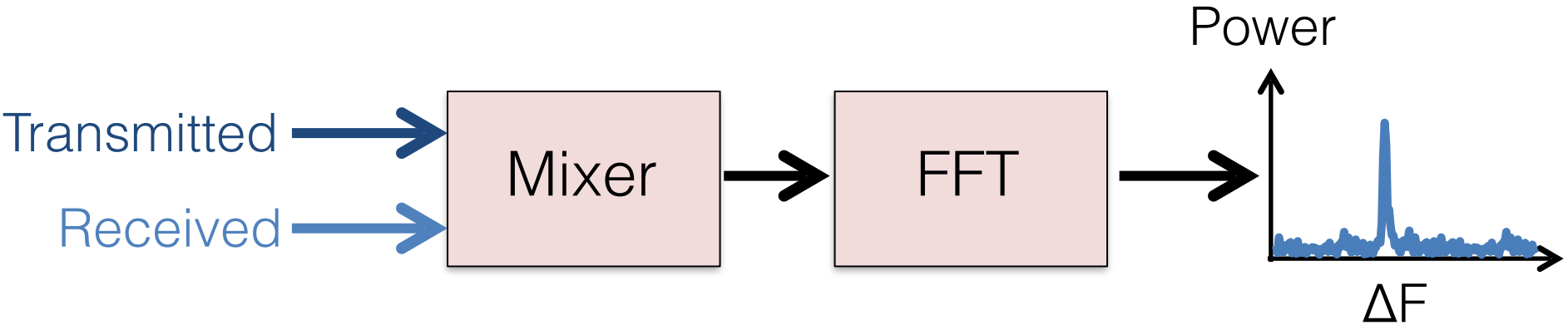
FMCW: Measure time by measuring frequency



How do we measure ΔF?

Measuring ΔF

- Subtracting frequencies is easy (e.g., removing carrier in WiFi)
- Done using a mixer (low-power; cheap)



Signal whose frequency is ΔF

Basics of Fourier

Measuring ΔF

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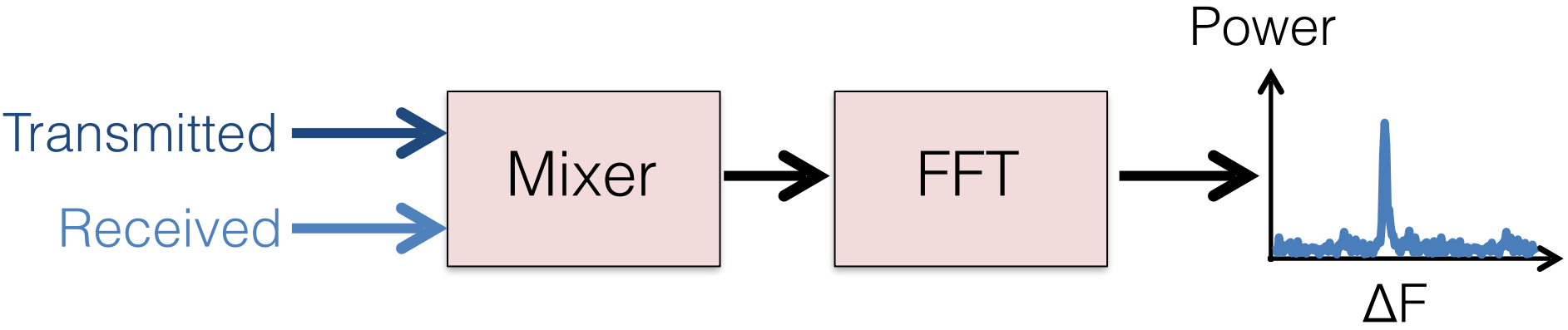
- Done using a mixer (low-power; cheap)



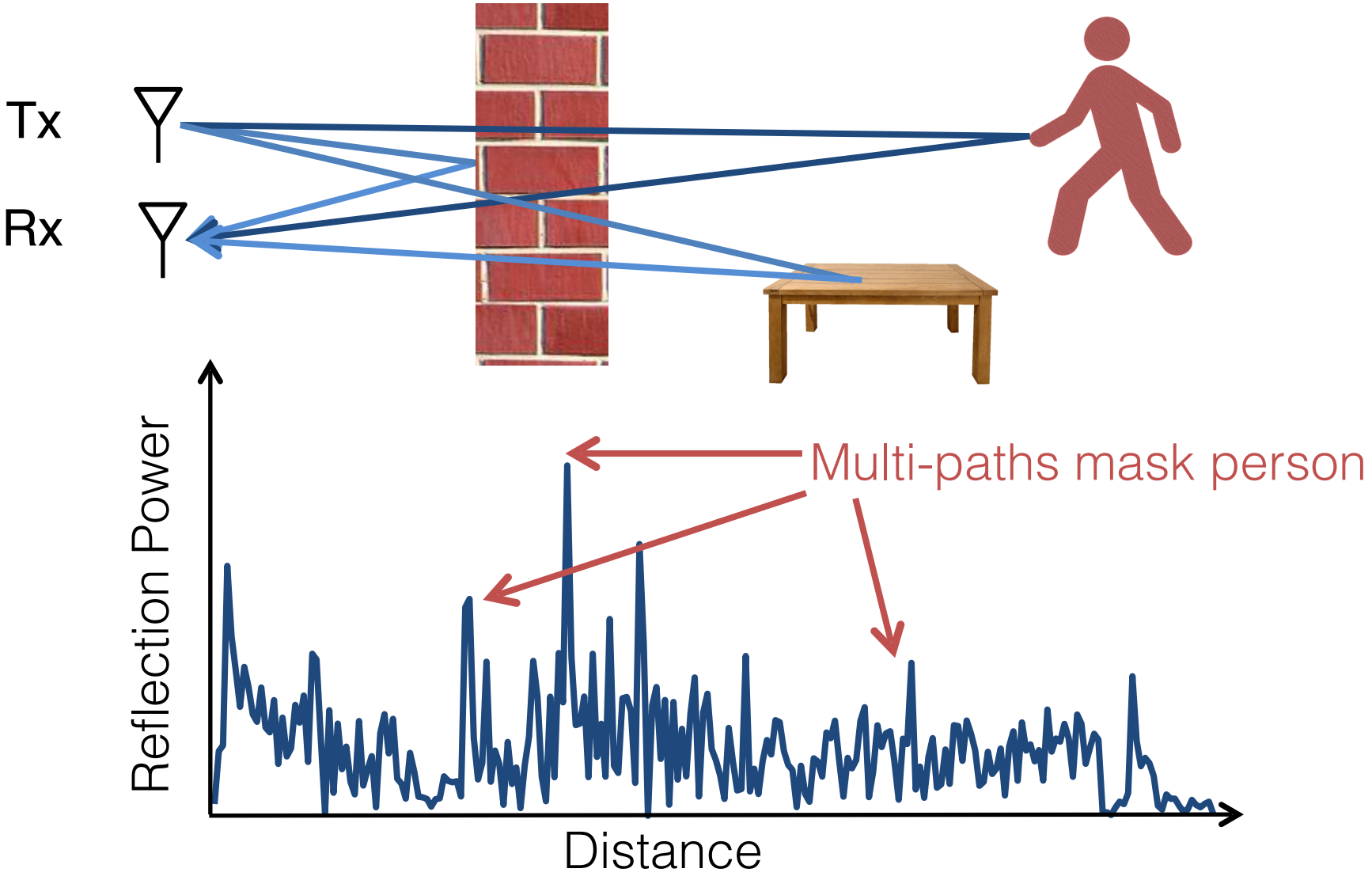
Signal whose frequency is ΔF

ΔF → Reflection Time → Distance

What is the resolution of FMCW?

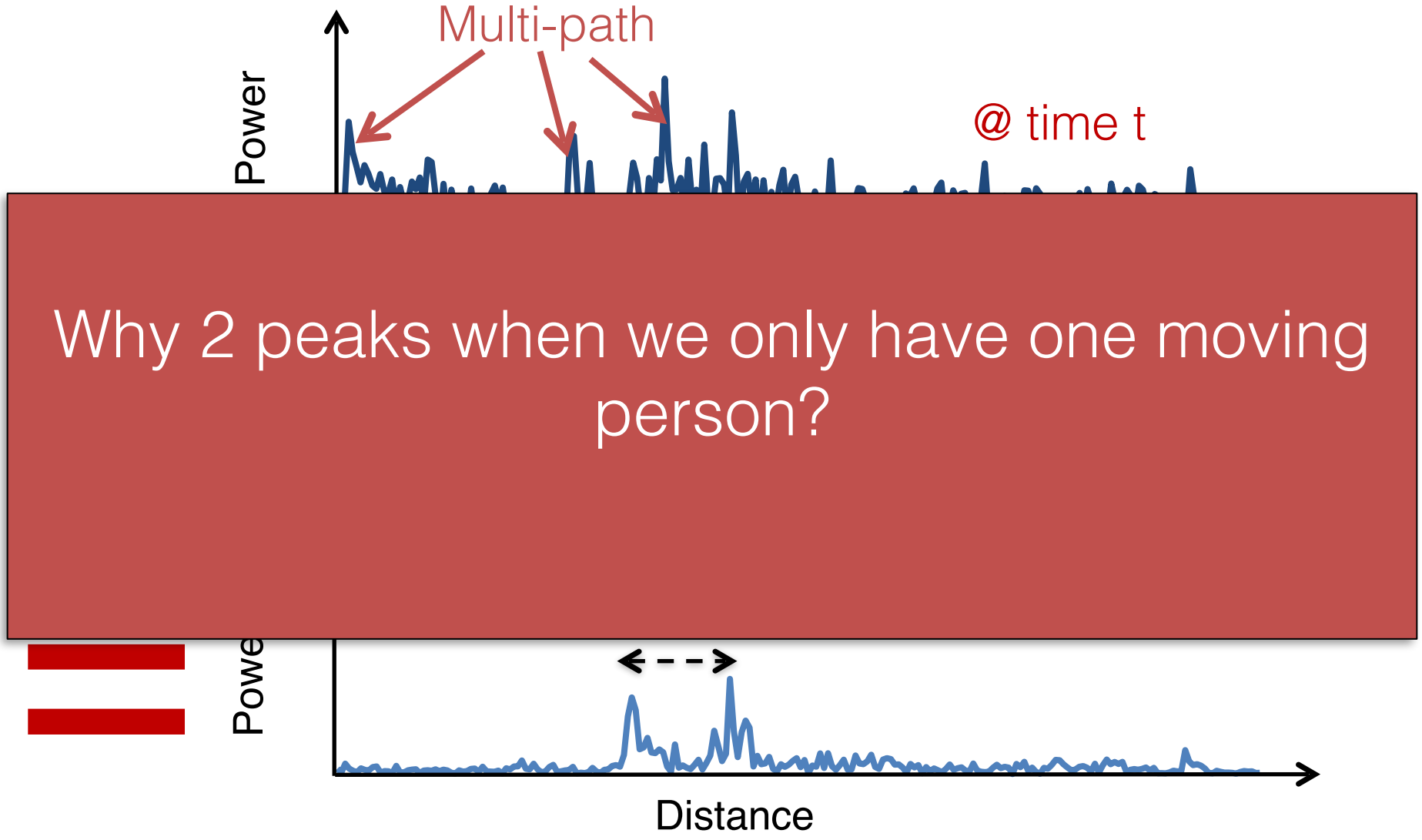
Are we done? Can we directly localize now?

Challenge: Multipath➔ Many Reflections

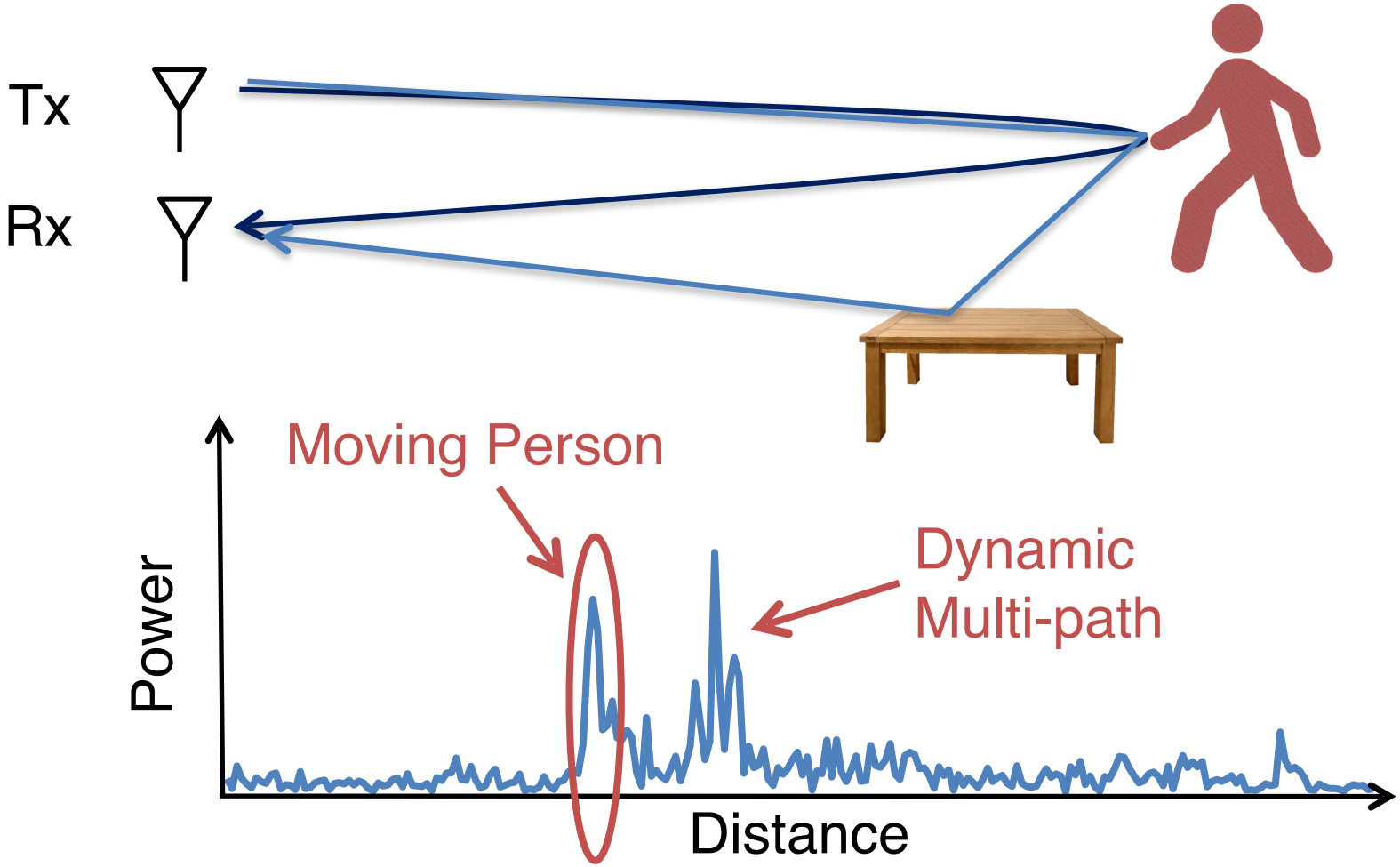


Static objects don't move

➔ Eliminate by subtracting consecutive measurements

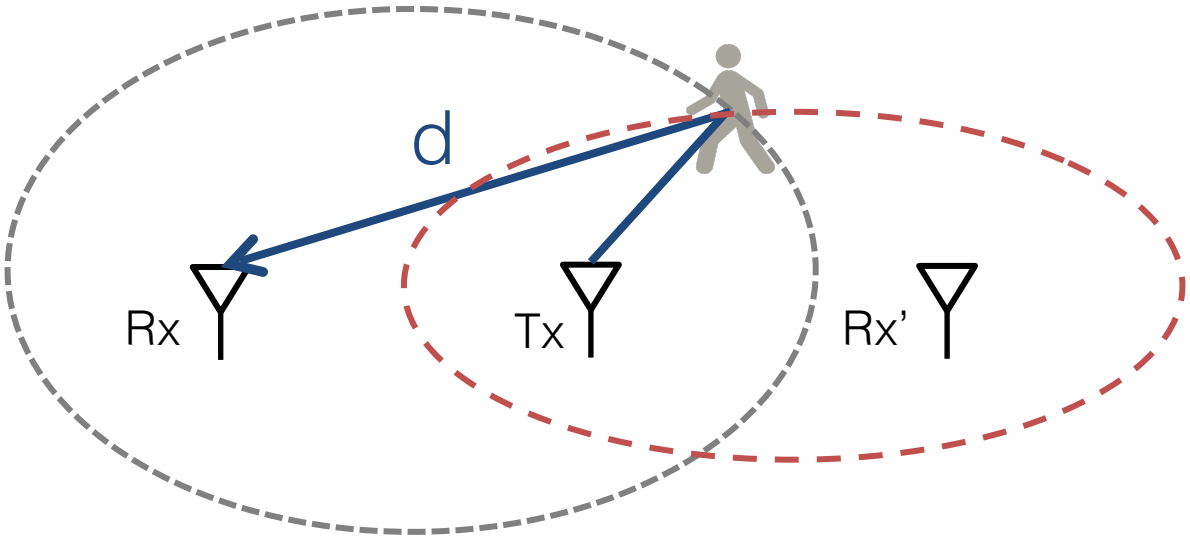


The direct reflection arrives before dynamic multipath!



Mapping Distance to Location

Person can be anywhere on an ellipse whose foci are (Tx,Rx)



By adding another antenna and intersecting the ellipses, we can localize the person

From Location to tracking

Limitations? Extensions