Topic Preview for Session:

Wireless Links

Yong Cui
Tsinghua University
@SIGCOMM 2018

Great success of wireless links

3G, 4G, 5G...

Wi-Fi

Bluetooth

RFIDs

swing card

Warehouse

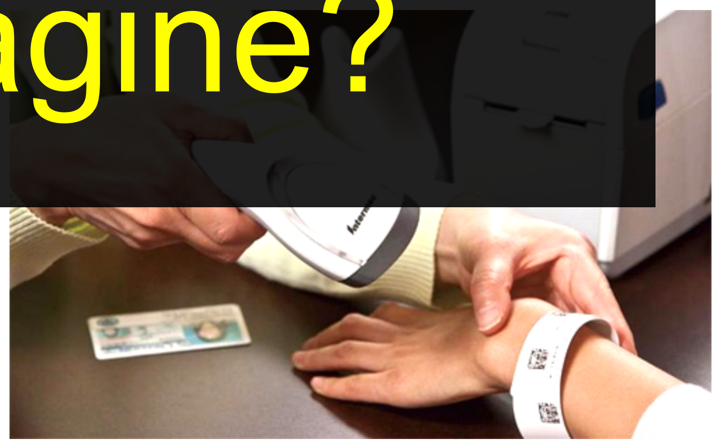
Medical

Great success of wireless links

3G, 4G, 5G... Bluetooth

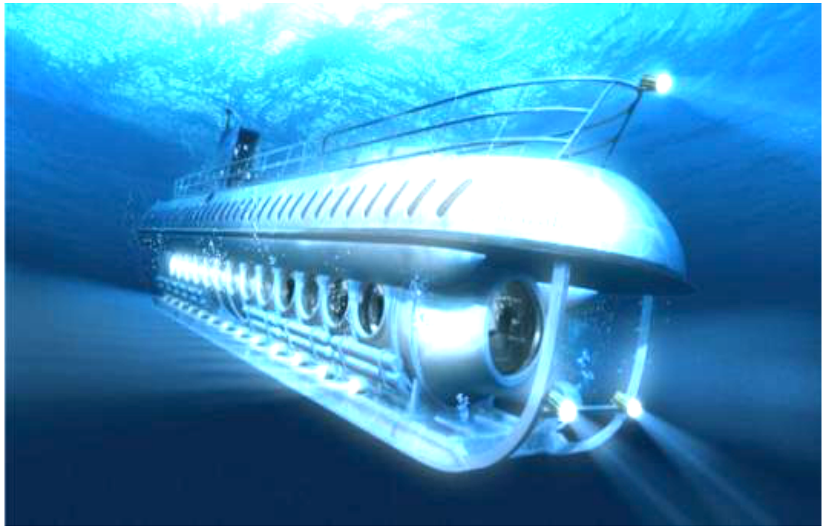
RFIDs

What kind of emerging wireless links can you imagine?



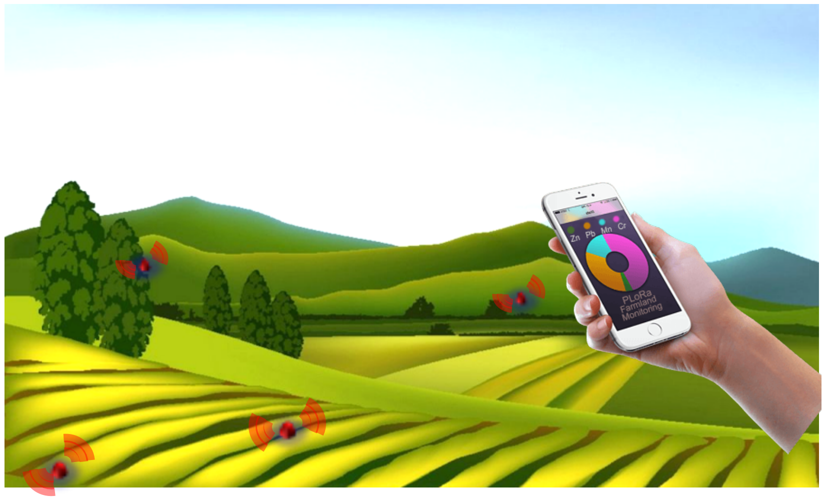
swing card Warehouse Medical

Emerging Wireless Links



Underwater Links

In-body links



Low power IoT links

Links over high speed mobility

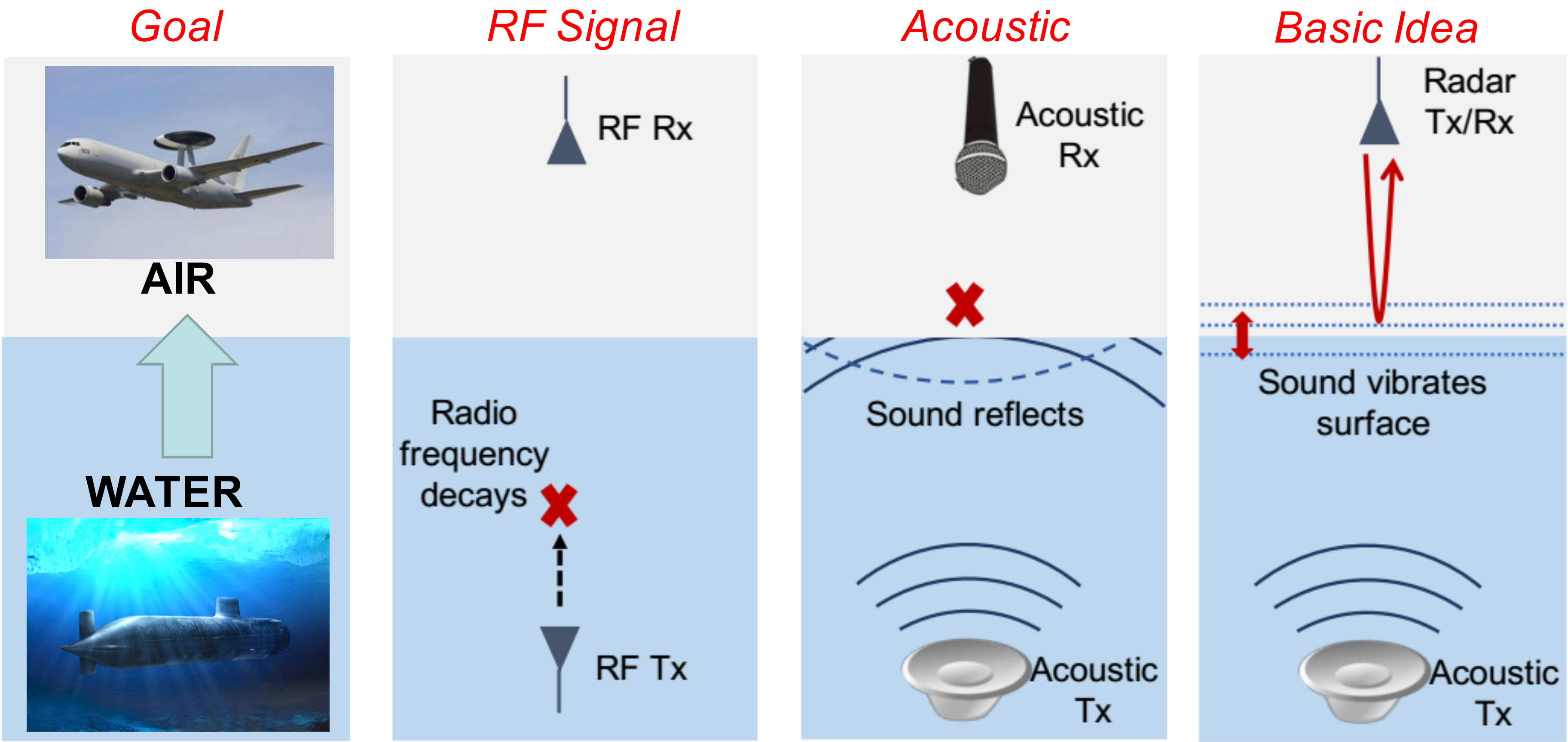
The Session of Wireless Links

- Networking across Boundaries: Enabling Communication through the Water-Air Interface
- In-body Backscatter Communication and Localization
- PLoRa: A Passive Long-Range Data Networks from Ambient LoRa Transmissions
- A Measurement Study on Multi-path TCP with Multiple Cellular Carriers on High-speed Rails

Networking across Boundaries: Enabling Communication through the Water-Air Interface

Francesco Tonolini, Fadel Adib
(MIT, USA)

Motivation and Novel Idea



- **Goal:** Sending from water to air (cross boundary)
  - **RF signal:** rapid attenuation in water
  - **Acoustic:** reflect off the water's surface
  - **Novel idea: <u>Acoustic vibration</u>** + **<u>RF sensing</u>**

Challenges and Solutions

Challenge 1: minute surface vibrations of acoustic waves

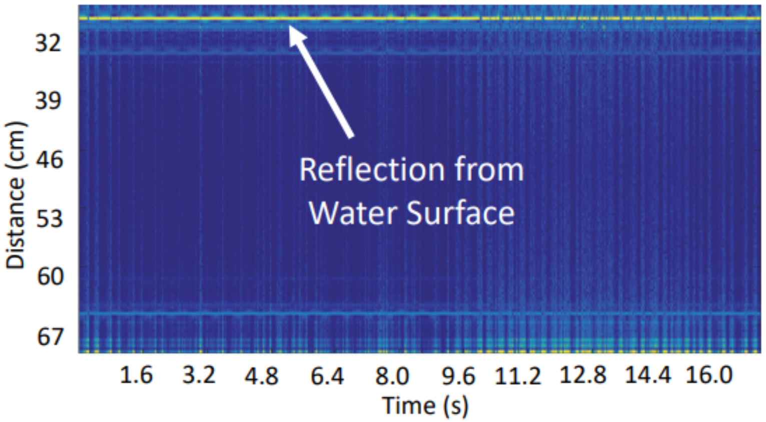
Solution: **Millimeter wave into an FMCW radar** to sense very minute surface vibrations

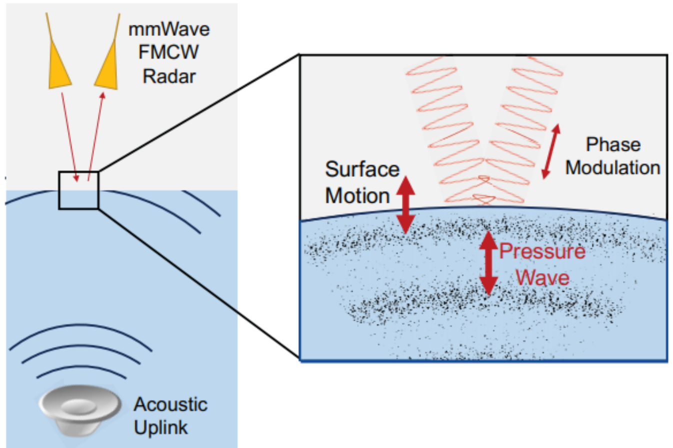
Challenge 2: Ocean waves - disturb the water surface

Solution: Filter out ocean waves in **frequency domain**

Challenge 3: choose the right modulation schemes to match the wireless channel quality

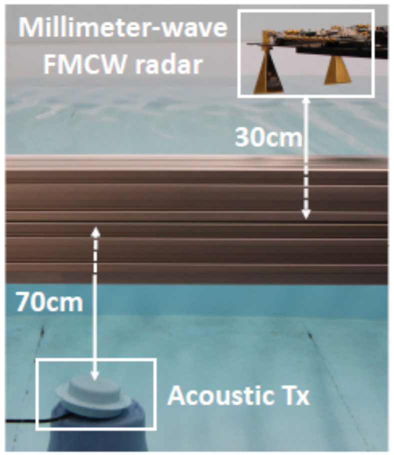
Solution: Utilize the unique properties of the new communication modality, design a **power- and rate-optimal modulation** scheme



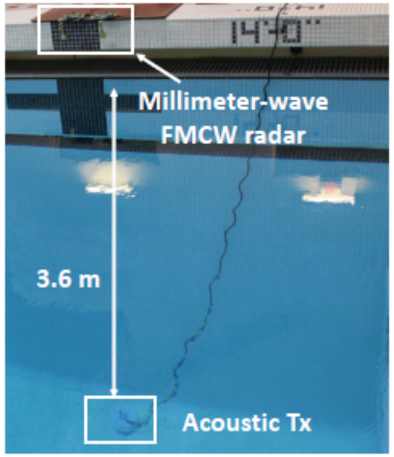


Implementation & Evaluation

- Implementation
  - Acoustic: 100Hz-200Hz
  - Modulation: OFDM
  - millimeter wave radar: Centered on 60GHz



(a) Tank Setup



(b) Pool Setup

- Evaluation
  - Two environments: water tank, swimming pool
- Results
  - Standard underwater bitrates up to 400bps
- Potential points
  - The bottleneck to cross the boundary?
  - Any novel technologies to improve the bandwidth, or achieve bidirectional comm.?
  - Do we have any other boundaries?

In-body Backscatter Communication and Localization

Deepak Vasisht, Guo Zhang (MIT, USA),
Omid Abari (UWaterloo, Canada),
Dina Katabi (MIT, USA),
Hsiao-Ming Lu, Jacob Flanz (MGH, USA)

Existing In-body Localization methods

X-ray localization

MRI localization

They are expensive, painful and harmful to patients

Existing In-body Localization methods

GI tract

Consuming large energy on RF transmission, but capsules are too small to carry battery

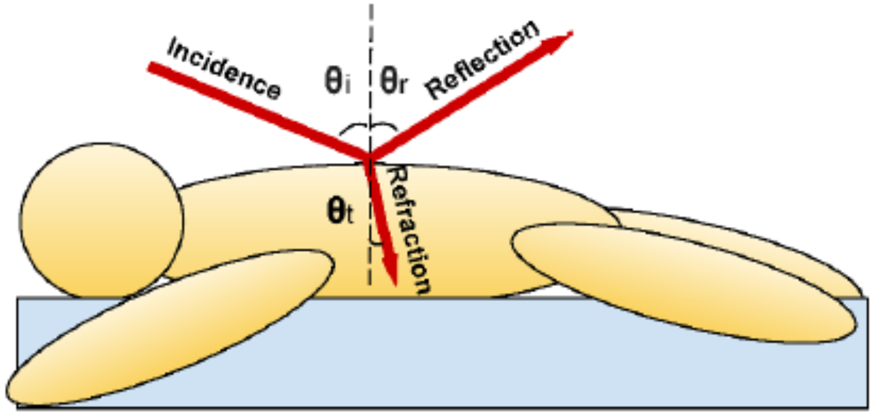
Opportunity: Backscatter is promising for communication and localization

The Challenges and Solutions

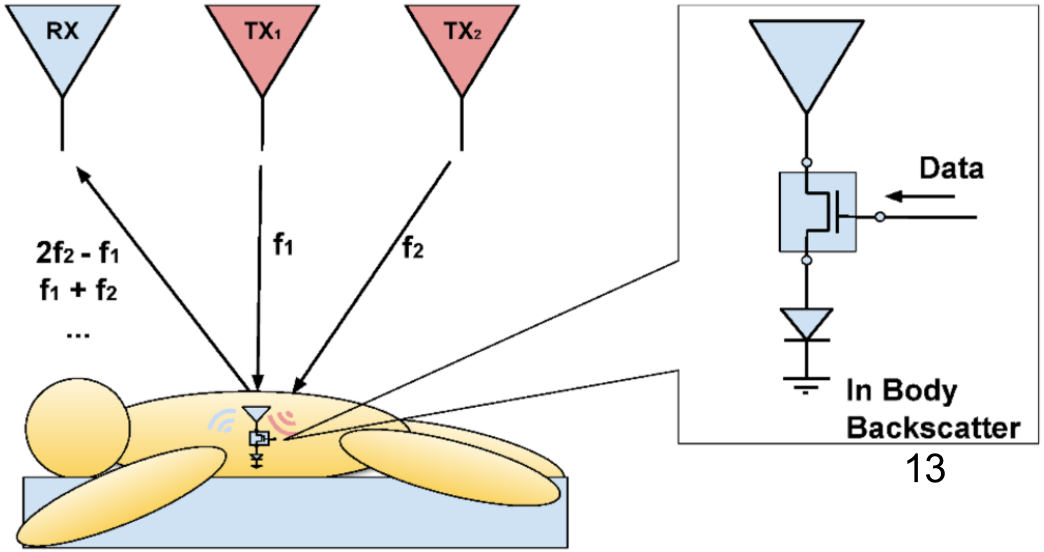
Challenge 1: Surface Interference

A large portion of the RF signal is reflected off the human surface.

How can we recognize the super weak reflected signal?



Solution 1: Using a non-linear tag to separate the backscatter reflections from all other reflections

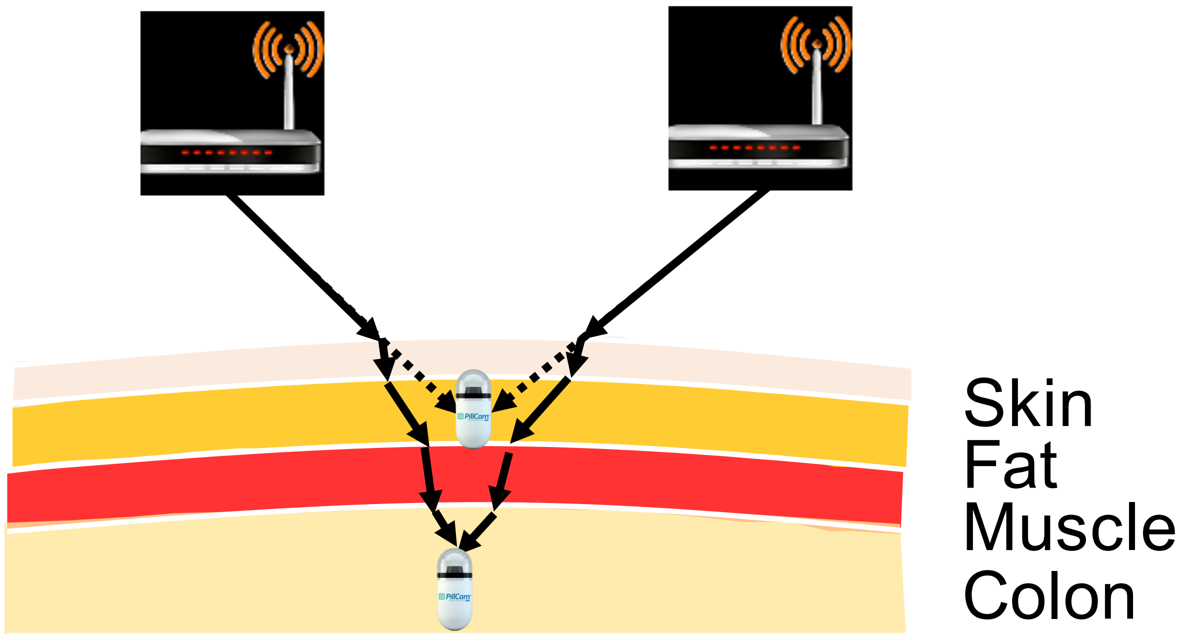


The Challenges and Solutions

Challenge 2: Signal Deflection

(the difference in speed between different medias causes the signal to significantly deflect)

Solution 2: Segmenting crooked paths to straight lines with linear splines



Implementation & Evaluation

- **Implementation**:
  - Devices: 4Usrp, two for transmitters, two for receivers
  - Transmitted frequencies: 830MHz, 970MHz
  - Test targets: whole chicken, pork belly
- **System setup**:



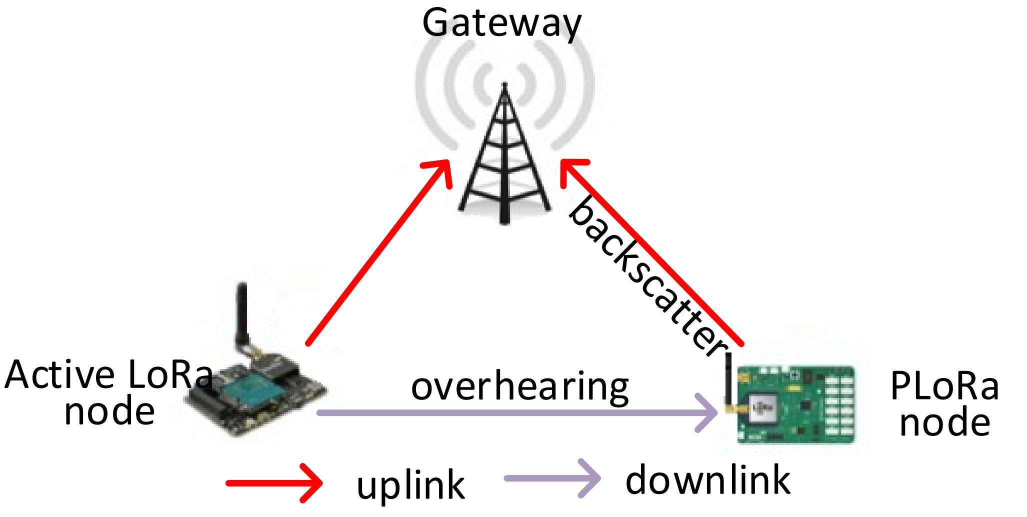
- **Evaluation:**
  - Backscatter communication: 1-8cm corresponds to SNR 11.5 -17dB
  - Localization accuracy: average 1.4cm

PLoRa: A Passive Long-Range Data Networks from Ambient LoRa Transmissions

Yao Peng (NWU, China), Longfei Shangguan (Princeton, USA), Yue Hu, Yujie Qian, Xianshang Lin, Xiaojiang Chen, Dingyi Fang (NWU, China), Kyle Jamieson (Princeton, USA)

Motivation

Requirement of
Smart Agriculture



One of the PLoRa Scenarios

Battery Free
Long Distance
Ambient Excitation

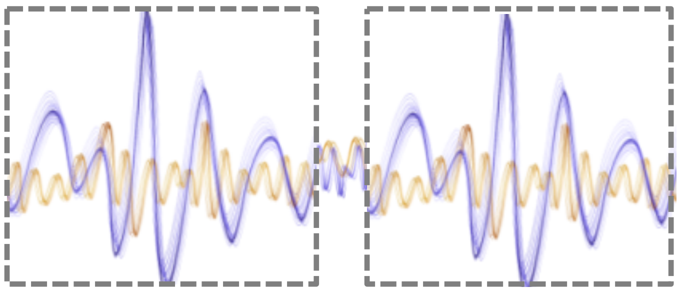
Key words: backscatter (battery free), ambient, long-range

The Challenges and Solutions

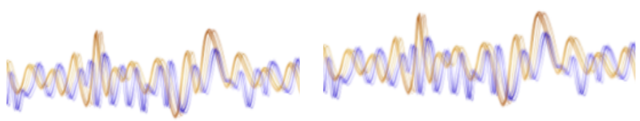
Challenge 1: Packet detection

LoRa packets are composed of time varying signal and have different packet intervals

Solution 1: Downsampling ADC and cross-correlation



LoRa packet



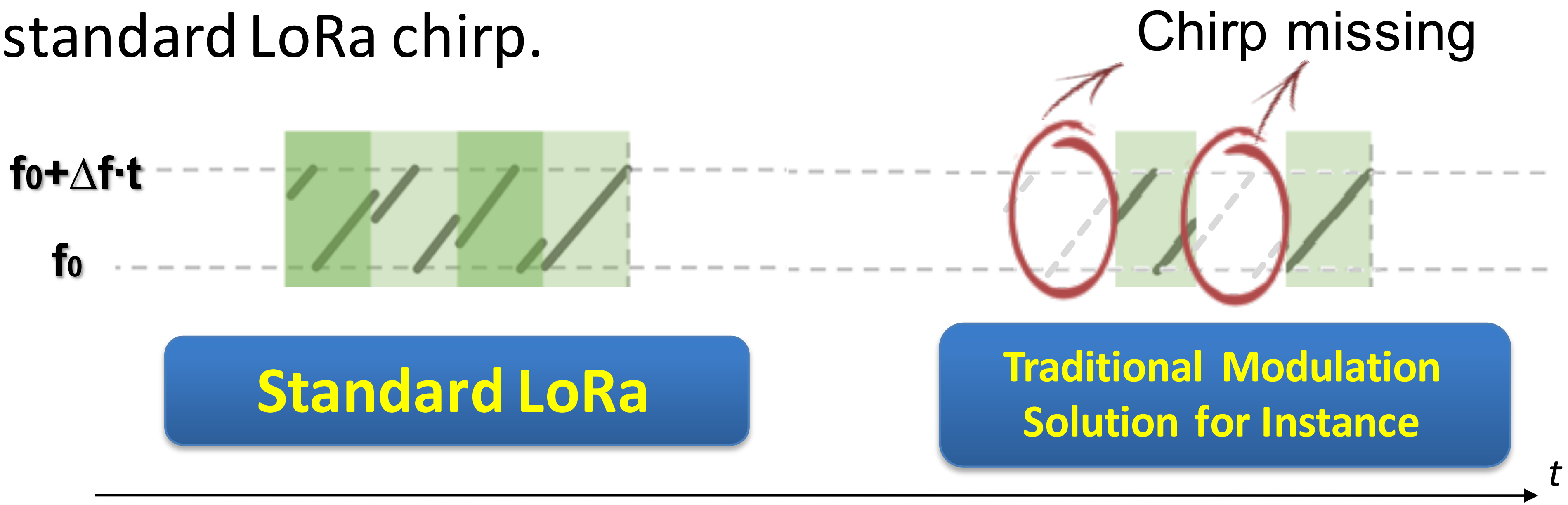
Noise

Where is the start LoRa packet?

The Challenges and Solutions

Challenge 2: Modulation

Modulate time-varying excitation signal into another standard LoRa chirp.

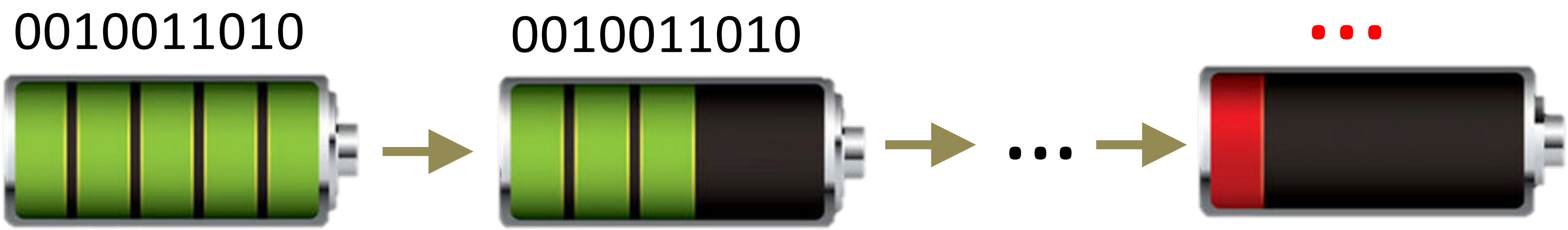


Solution 2: Blind modulated baseband signal with the incoming LoRa chirp.

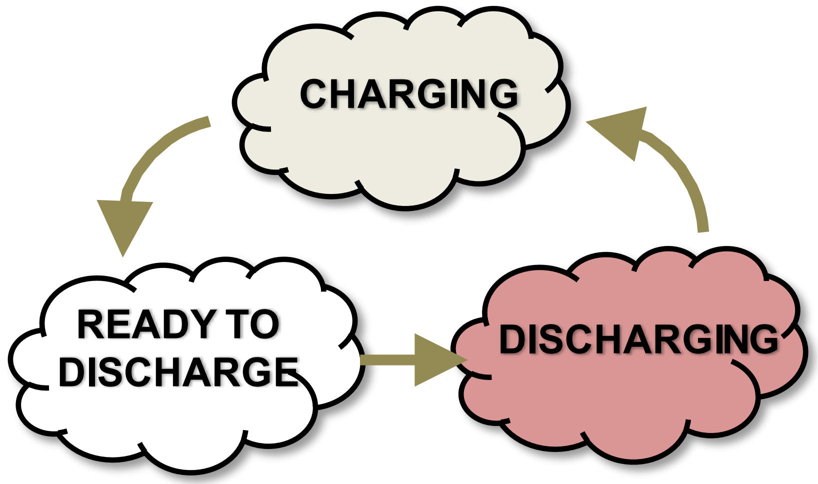
The Challenges and Solutions

Challenge 3: Energy Management

The passive tag may soon loss its data due to its energy exhausted.



Solution 3: Putting forward a finite state machine to manage the tag state.



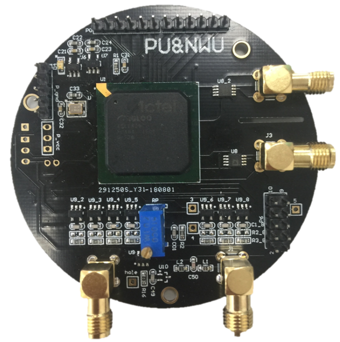
Implementation & Evaluation

➢Implementation:

- PLoRa Tags
- USRP 2954
- Commercial TX/Rx: LoRa Sx1276/LoRa Gateway

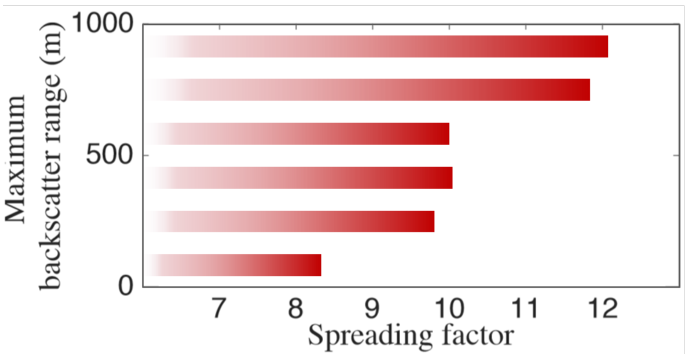
PLoRa tag 4. 0

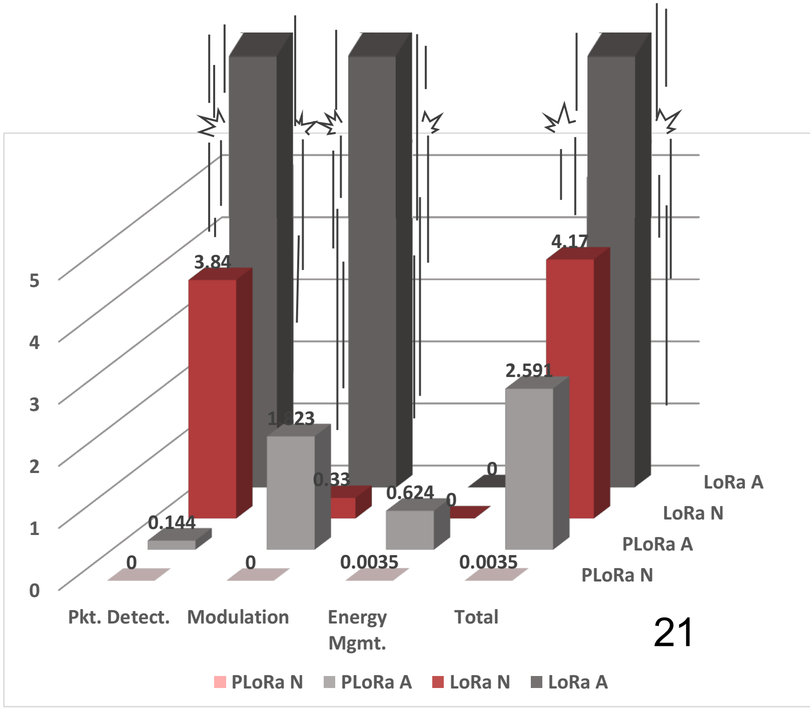
PLoRa tag 5. 0



➢Evaluation:

- Maximum backscatter range: 1.1km
- Total energy consumption: 3.52μW





A Measurement Study on Multi-path TCP with Multiple Cellular Carriers on High Speed Rails

Li Li, Ke Xu, Tong Li, Kai Zheng,
Chunyi Peng, Dan Wang, Xiangxiang Wang,
Meng Shen, Rashid Mijumbi

Can we have *High Speed* ?

>300 km/h	38,000 km	310 km/h	1.7 billion	30%
	Length	**Speed**	**Passenger**	**Growing**

High speed mobility

High speed Internet

Measurement Study

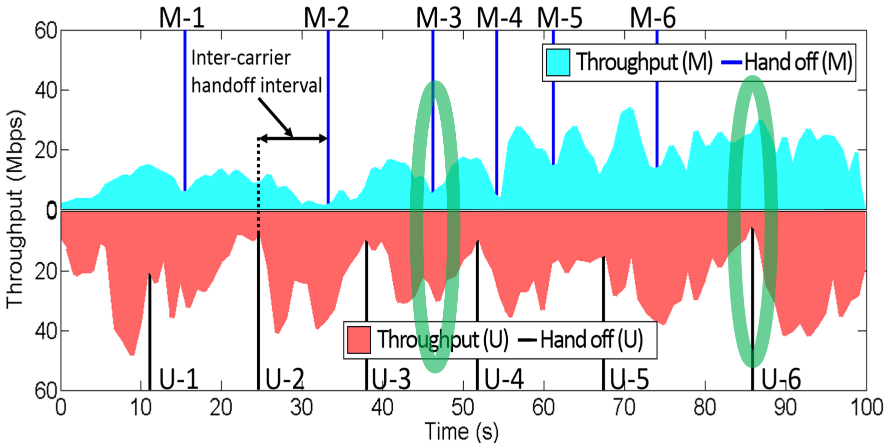
- A measurement study on the TCP behaviors in HSPA+ networks on high-speed rails [INFOCOM 2015]
- A Longitudinal Measurement Study of TCP Performance and Behavior in 3G/4G Networks over High Speed Rails [TON 2017]
- A Measurement Study on Skype Voice and Video Calls in LTE Networks on High Speed Rails [IWQoS 2017]

⇩

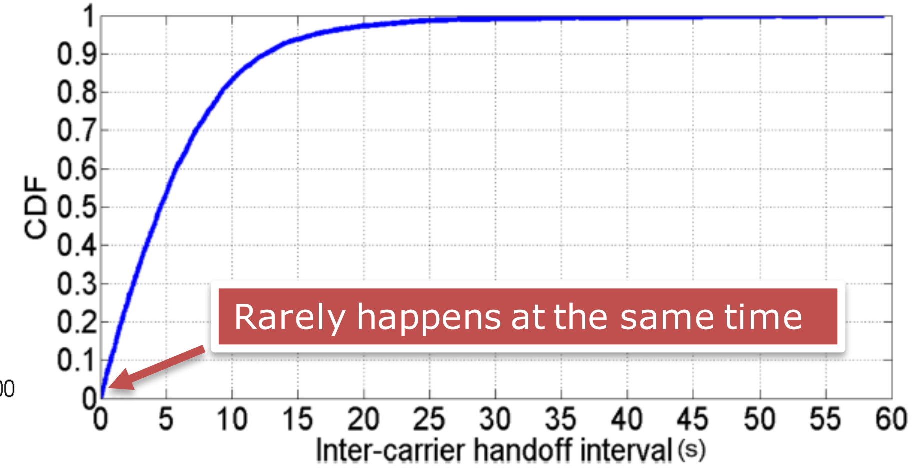
Frequent handoff is the main cause of TCP performance degradation

Carrier Complementarity

Making use of the difference in handoff time



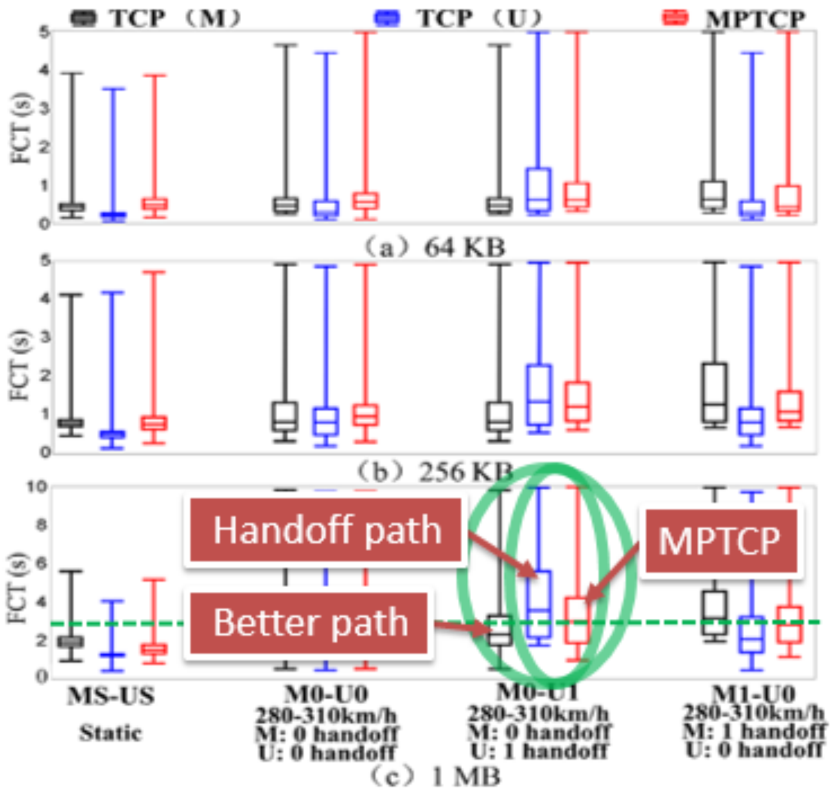
An example of two complementary carriers



CDF of inter-carrier handoff interval

To explore potential benefits of using Multi-path TCP (MPTCP)

Mice Flows



FCT of mice flows (<1 MB)

M: Carrier M U: Carrier U

Metrics measured

- Robustness: If MPTCP outperforms **either** of the two single-TCP flows

FINDING: MPTCP improve robustness over TCP

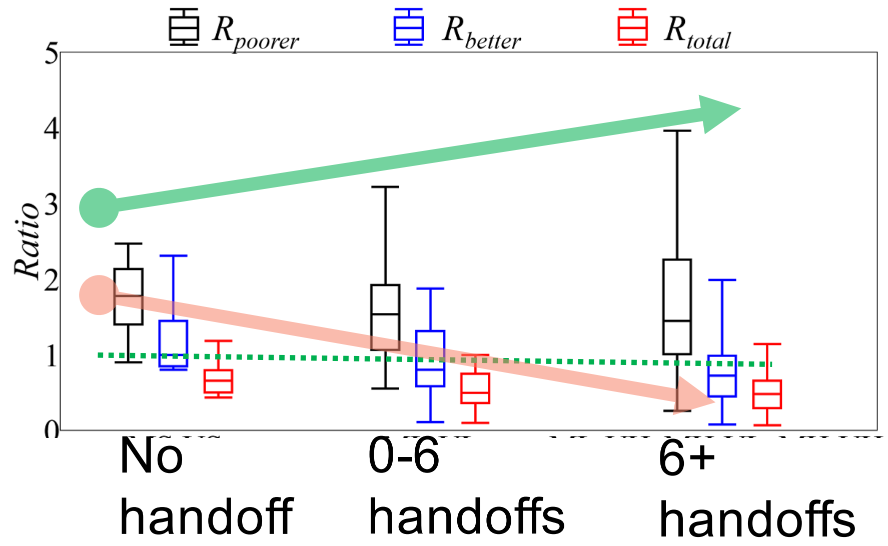
- Efficiency: If MPTCP outperforms **both** single-TCP flows

FINDING: MPTCP cannot improve efficiency over TCP

Elephant Flows

FINDING: MPTCP improves robustness, but not efficiency

- Reasons behind
  - Mice flow: inefficient sub-flow establishment
  - Elephant flow: inefficient congestion control and scheduling to frequent handoffs
- Metric: average rate during 100 seconds
- Variable: train speed and number of handoffs suffered

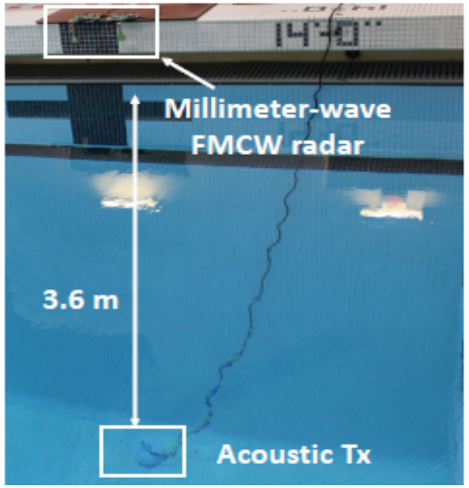


Insights and Suggestions

- **Finding**: MPTCP with two carriers
  - Significant improvement in robustness
  - Efficiency of MPTCP is far from satisfactory
- **Root causes**: frequent handoffs
  - Sub-flow establishment
  - Scheduling, congestion control
- **Suggestions**: Handoff detection/prediction
  - Establish new sub-flows outside a predicted handoff
  - Retransmit lost packet of handoff path via others
  - Differentiate handoff and congestion. Coupled CC that is not loss-based. Or uncoupled!

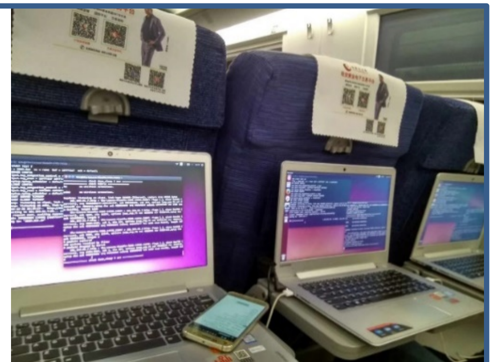
ACK authors' effort of the session

Chicken, water tank, or 1.1km distance?



Measurement for MPTCP

Train tickets in one day



SIM cards

22-month, 82,266 km, 2.8 TB data
Twice of The Earth circumference

So, it is going to be an exciting session!

4:30 pm - 6:10 pm

Tuesday, August 21, 2018