



Wireless Two-way Interferometry (Wi-Wi) as Alternative Technology for GNSS- Denied Environments

Nobuyasu Shiga, Satoshi Yasuda

National Institute of Information and Communications Technology

(NICT) – Japan

2024/9/16

ION GNSS+ 2024, CGSIC

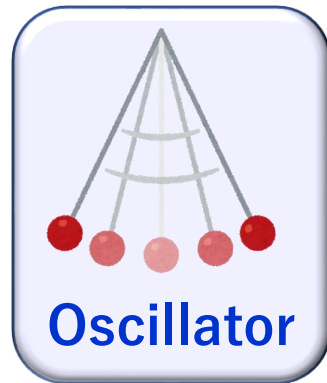




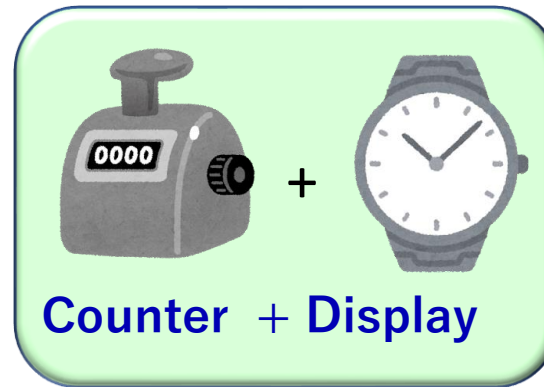
NICT make a clock for Japan (JST)



=



+



+



Space-Time standards group

Ultimate Oscillator
(Atomic clock)



Cs Atomic clock

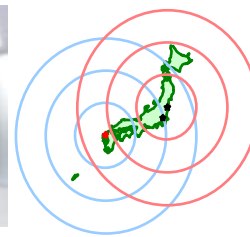


Sr Optical Atomic clock

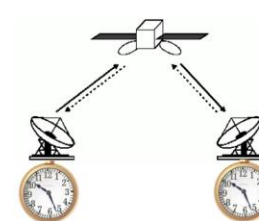
Generation and Dissemination of JST



Generation of JST

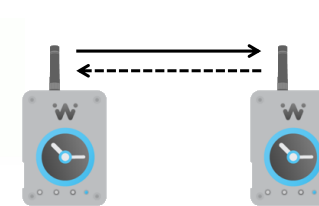


Radio Clock



TWSTFT

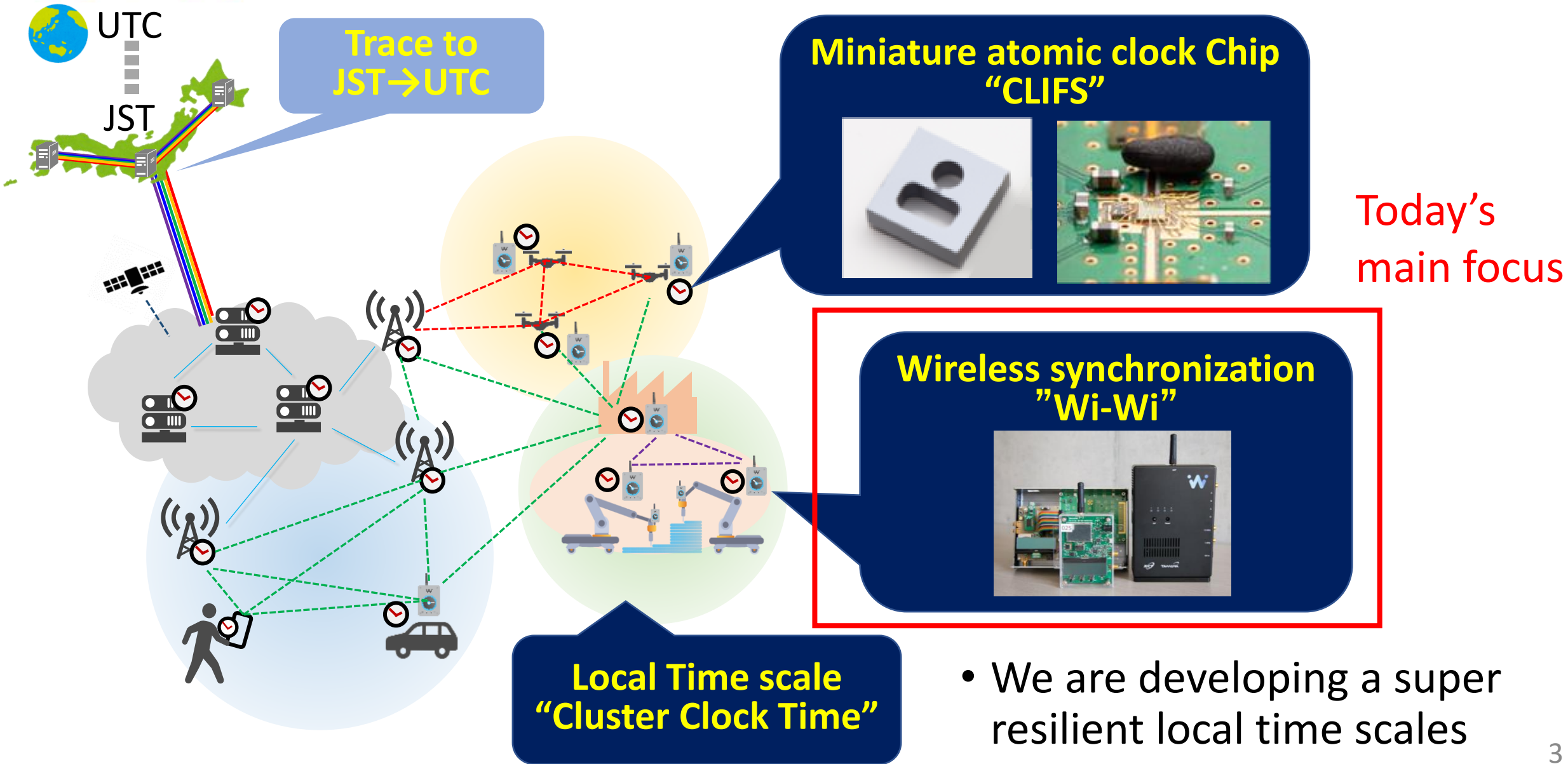
Synchronization



Wi-Wi



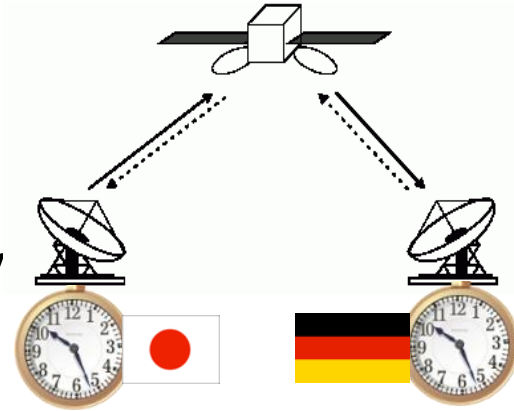
Our Future vision: Tracing User clock to UTC



WiWi Wireless 2Way interferometry (Wi-Wi)

Pre-existing technology

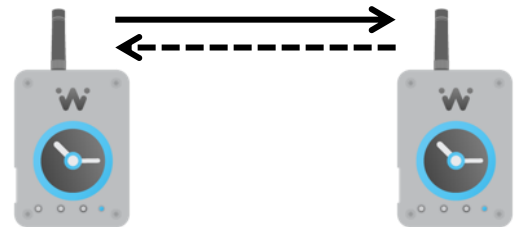
Two-way satellite time and frequency transfer (TWSTFT)



measurement of **time difference** and **transmission time** via satellite communication.

New!

Wireless two-Way interferometry (Wi-Wi)

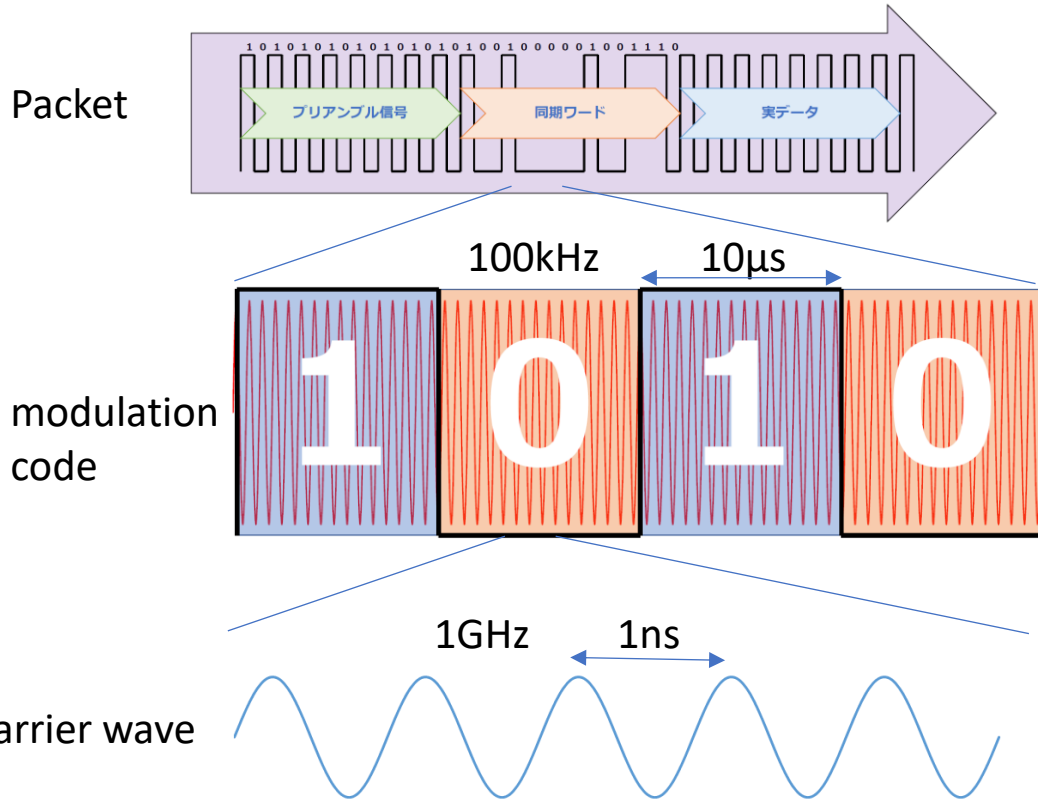


measurement of **time** and **distance** via wireless communication.

We adopted the satellite technology to achieve **Time synchronization** (pico second accuracy) and **Distance measurement** (mm accuracy) at extremely high precision with Low cost and small size.

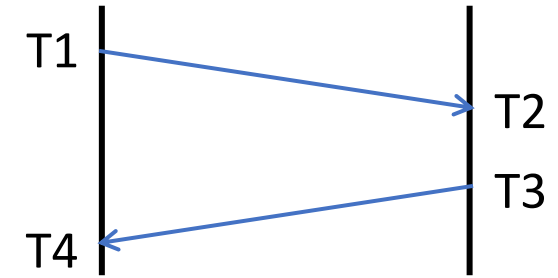
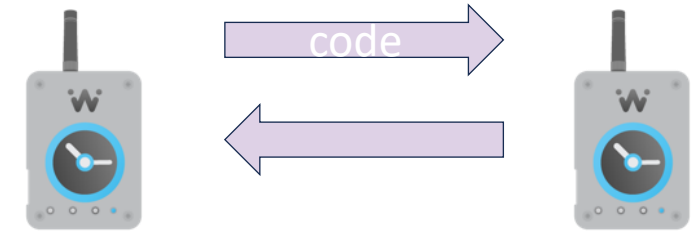


Phase and Time comparison

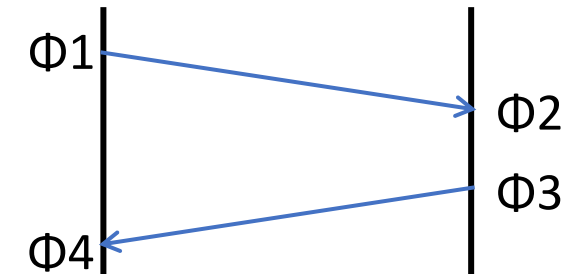
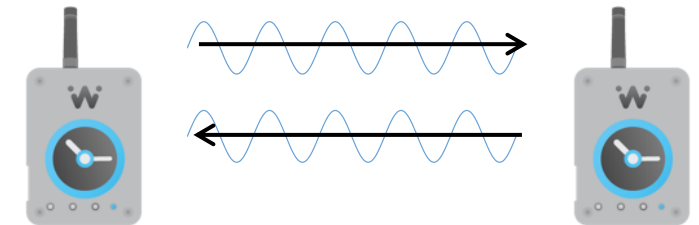


- We take advantage of Carrier frequency (similar to White Rabbit)

Time comparison
“Synchronization”
Time alignment



Phase comparison
“Syntonization”





Prototype modules



- 920MHz wireless communication module
- Fully compatible with IEEE 802.15.4
- Range 200m(20mW)/5km(250mW)
- Phase synchronization jitter: 16ps
- Time synchronization: 30ns



Satoshi Yasuda
made them all!



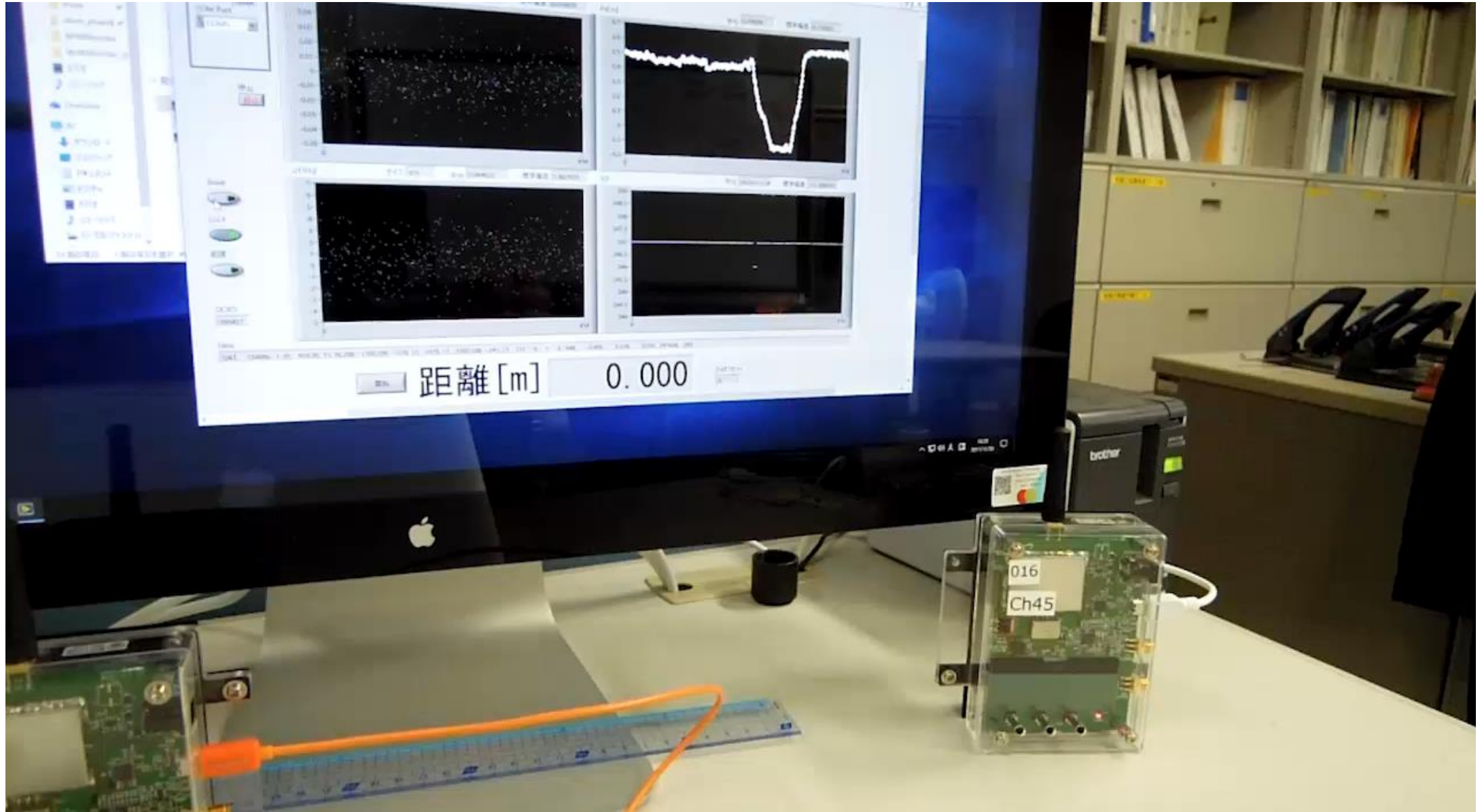
Demonstration of Synchronization



Wi-Wi Module Release 6 Synchronization Demo



Demonstration of distance variation

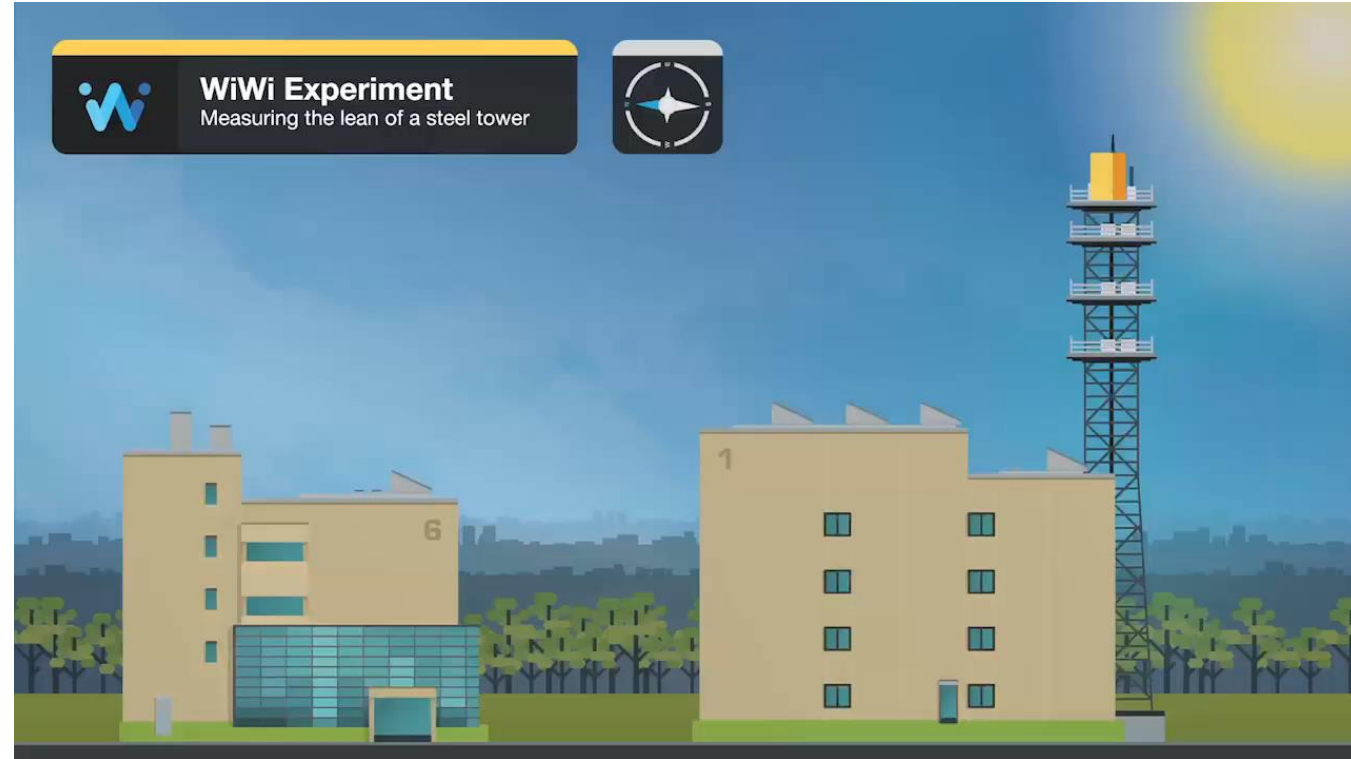
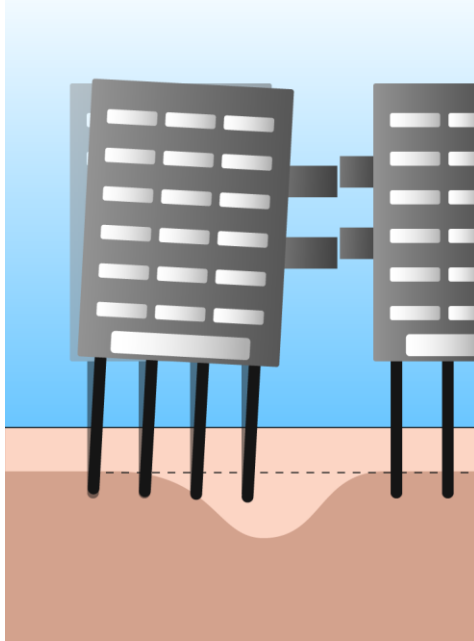




Application Example 1

Monitoring infrastructure

Tiny tilt of building



Current issue

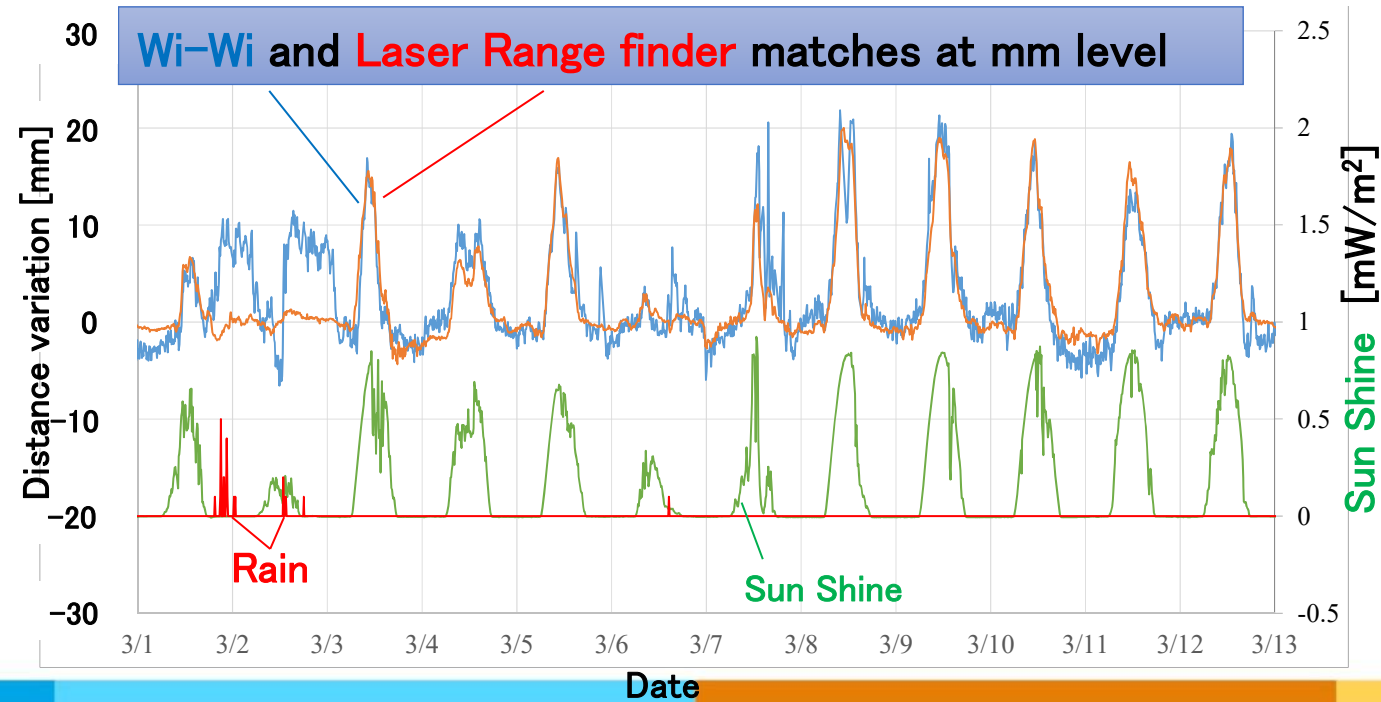
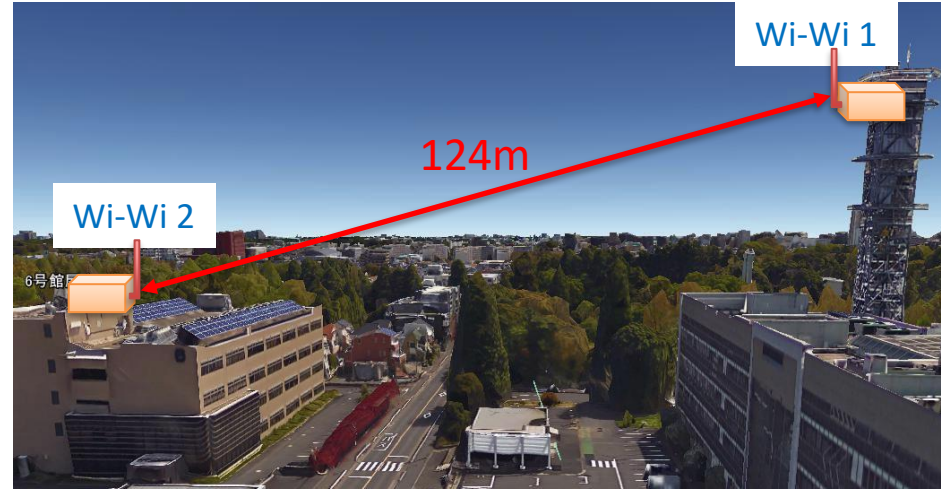
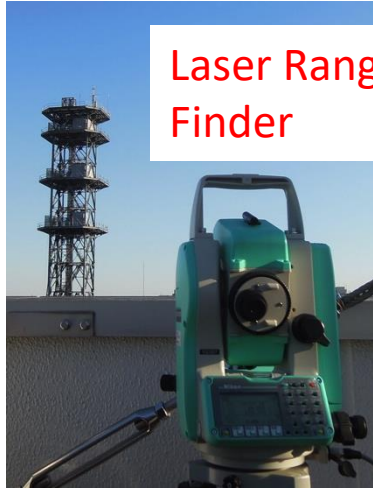
There is no other way to trace the small distance change (mm) for long run.

Wi-Wi provides

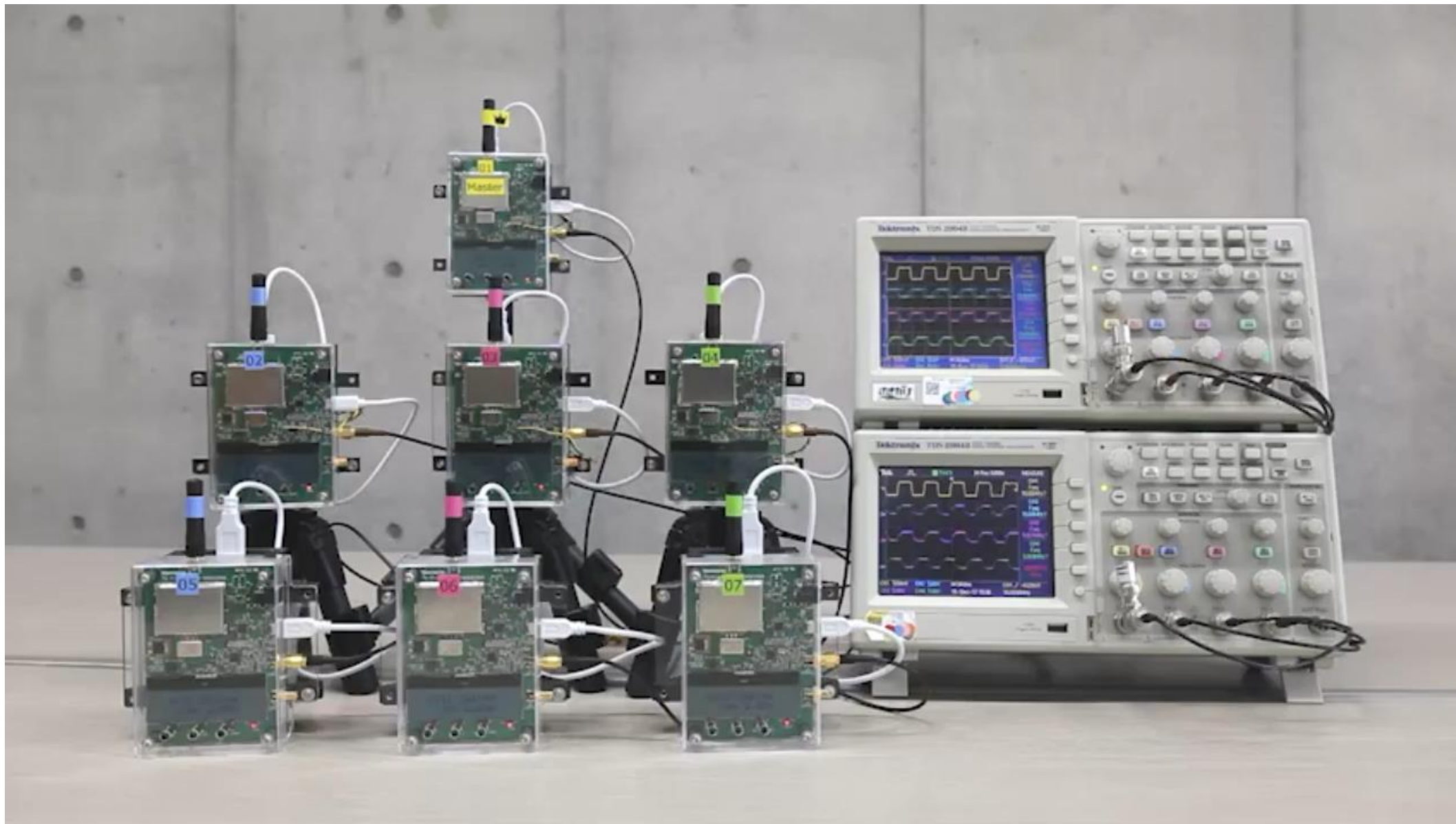
Cheap and handy system to monitor the distance variation at **1mm precision**



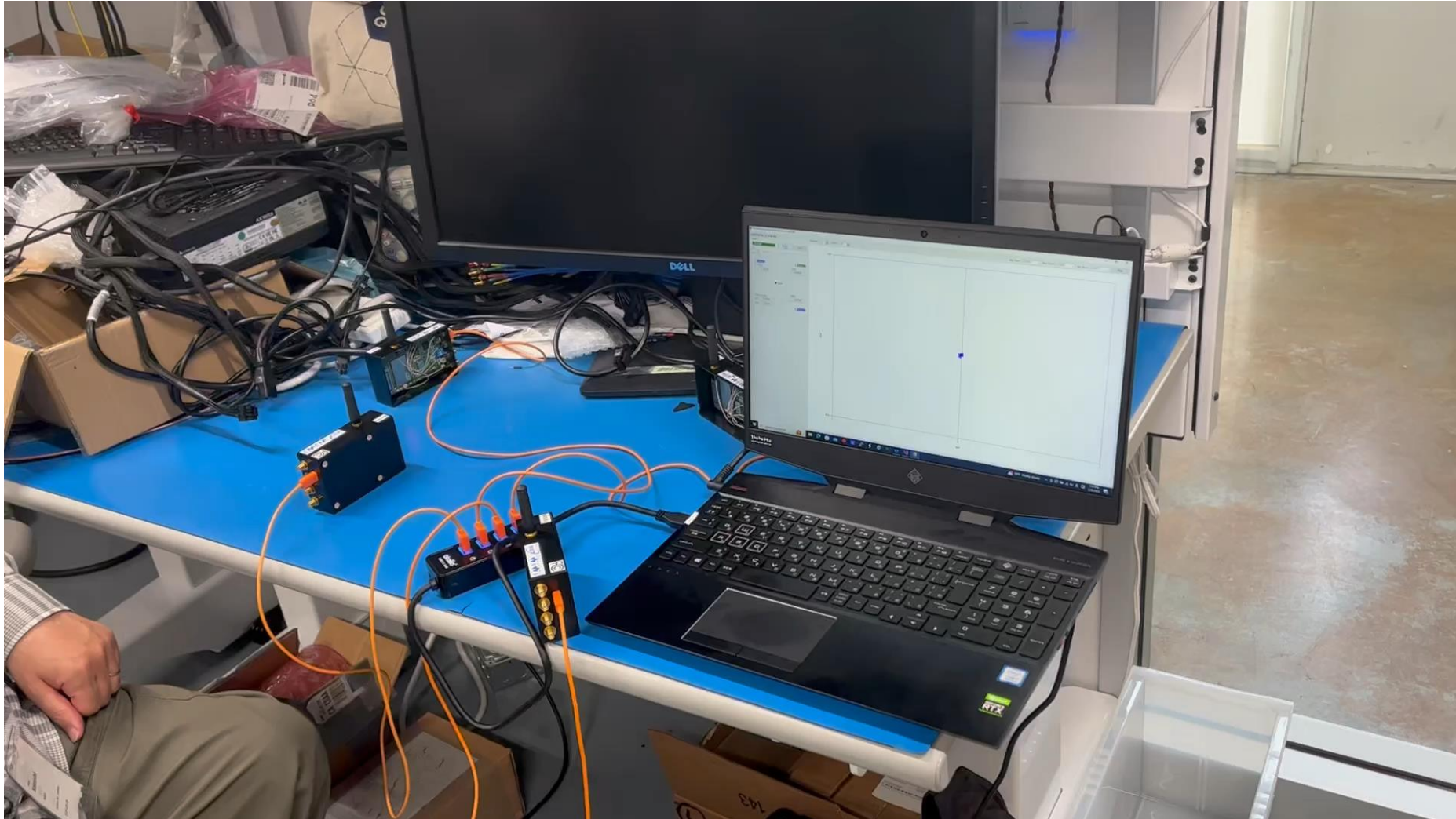
Example 1 Monitoring Infrastructure



7 modules synchronized

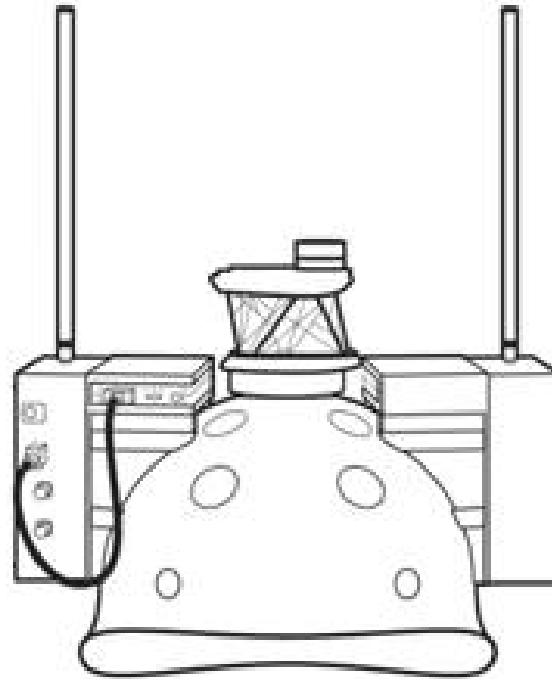


wii Quick demo of indoor motion sensing





2D position variation





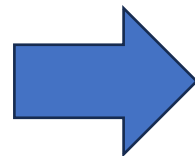
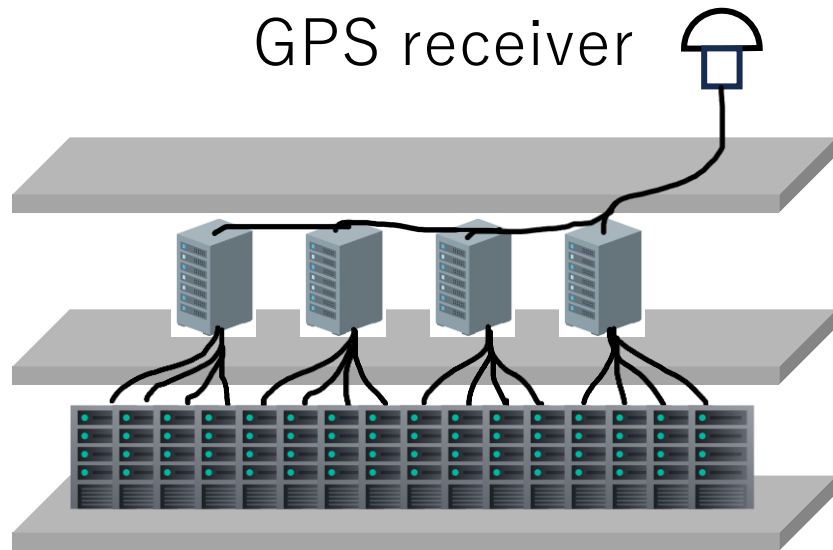
Data Center Application (Indoor synchronization)

Wired



GPS

GPS receiver

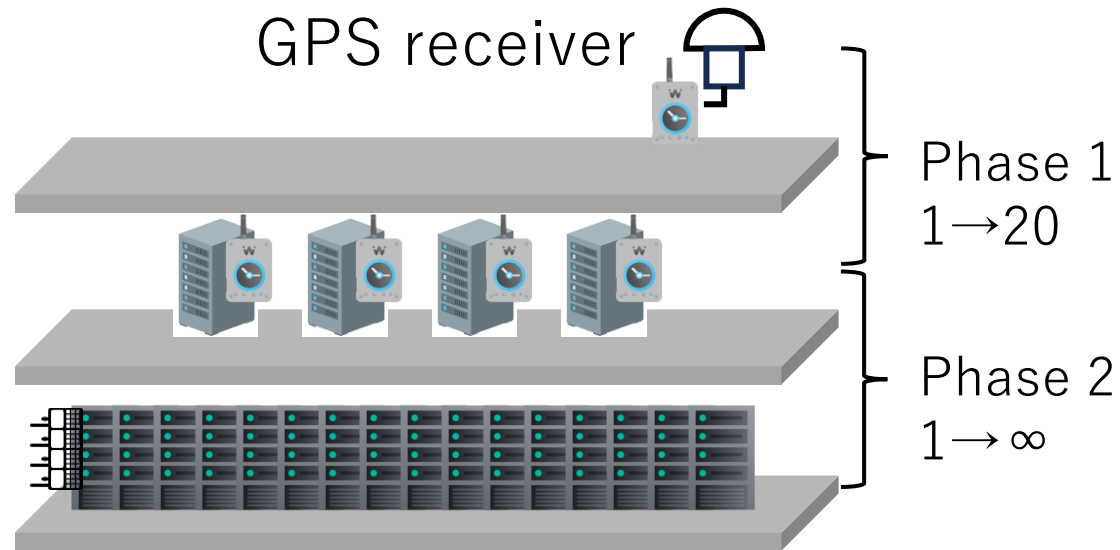


Wireless



GPS

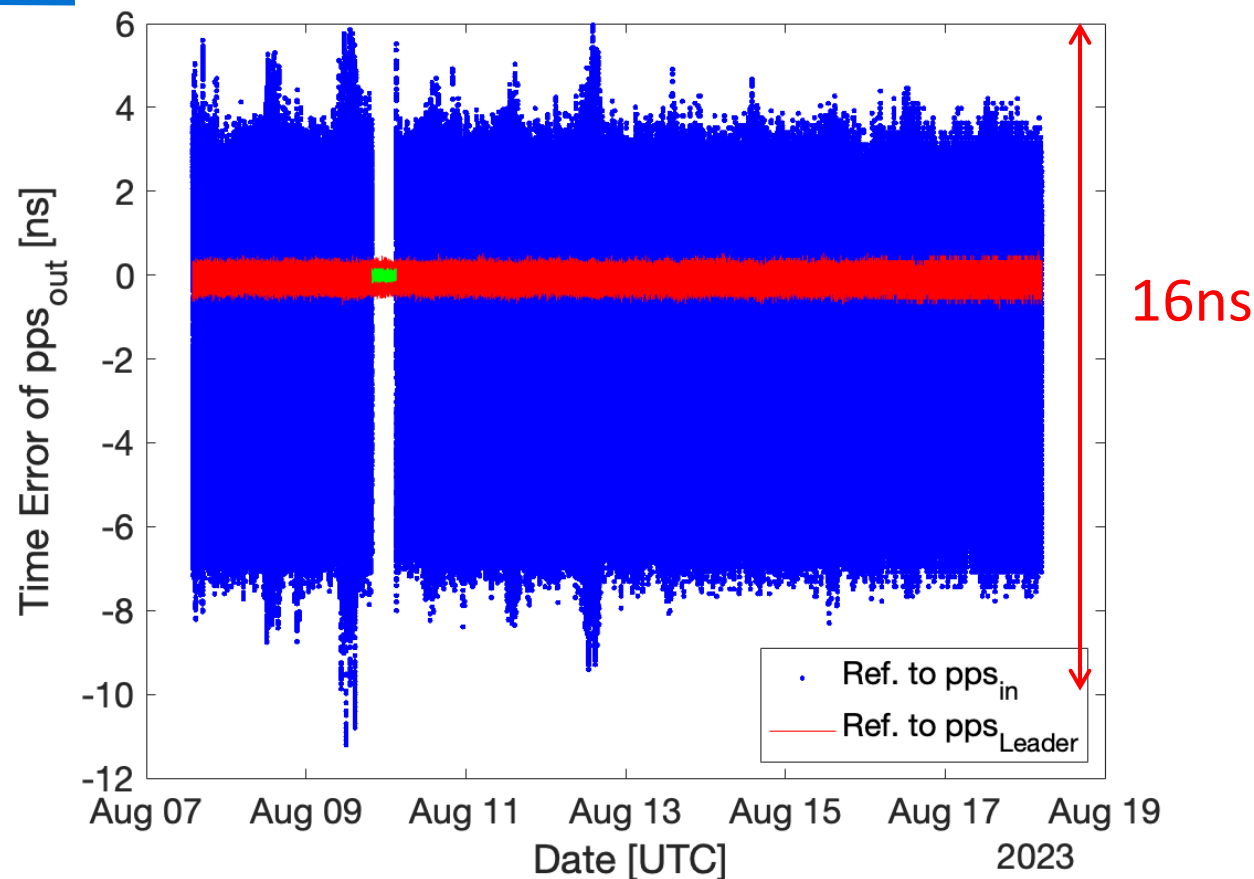
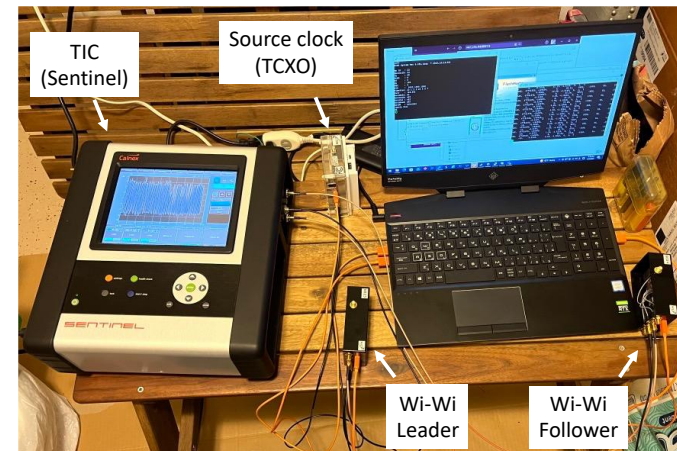
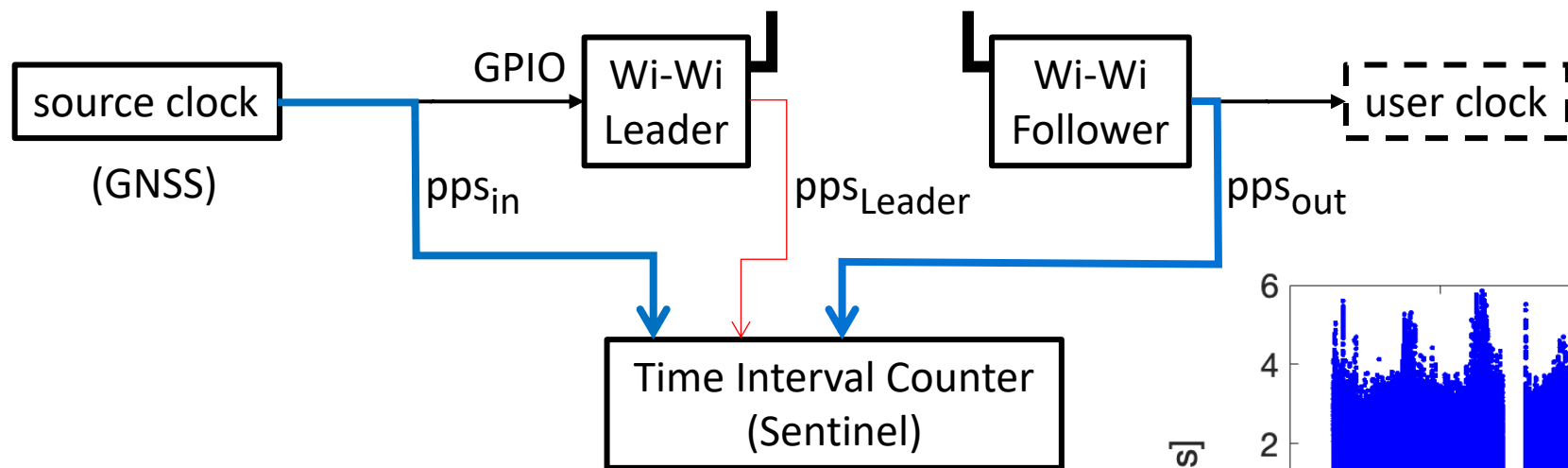
GPS receiver



- Precise wireless clock transfer via Wi-Fi in a GNSS denied environment



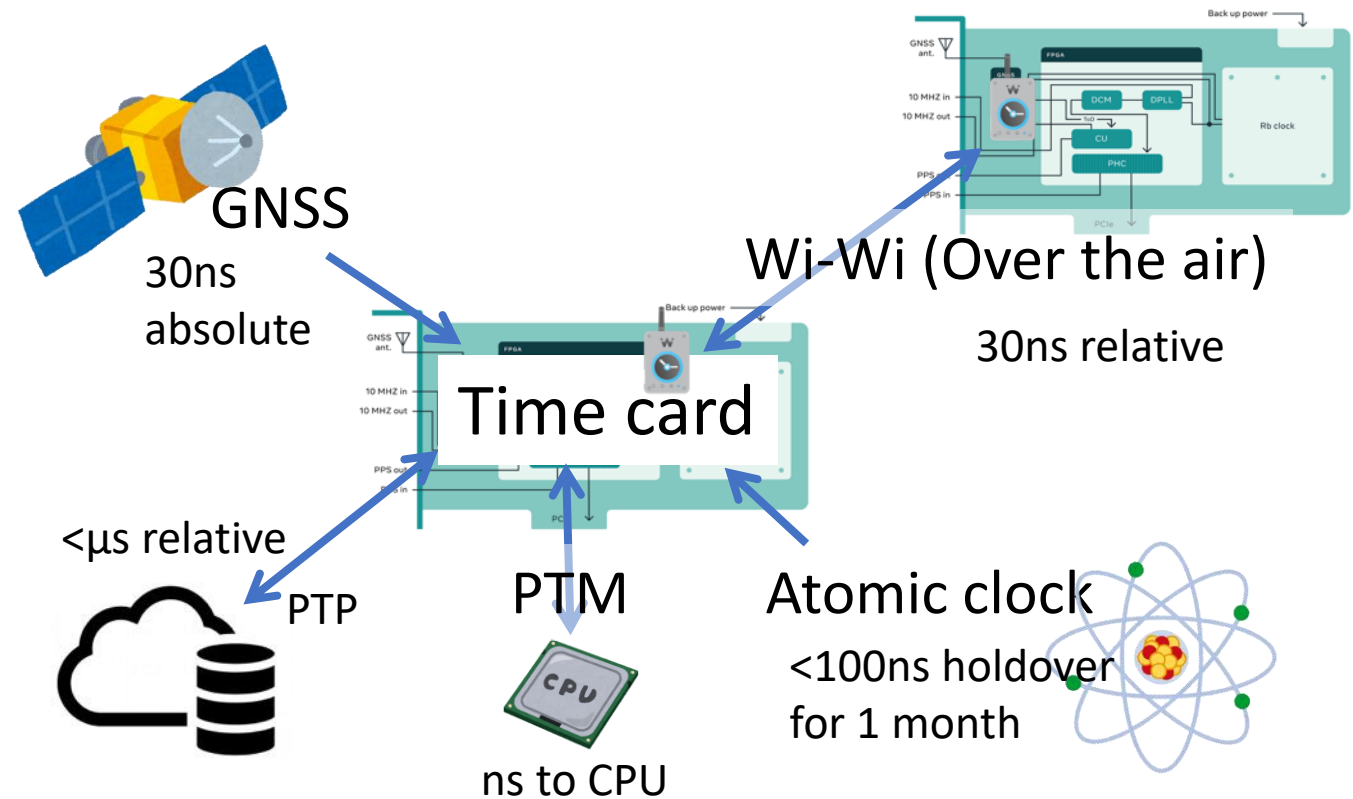
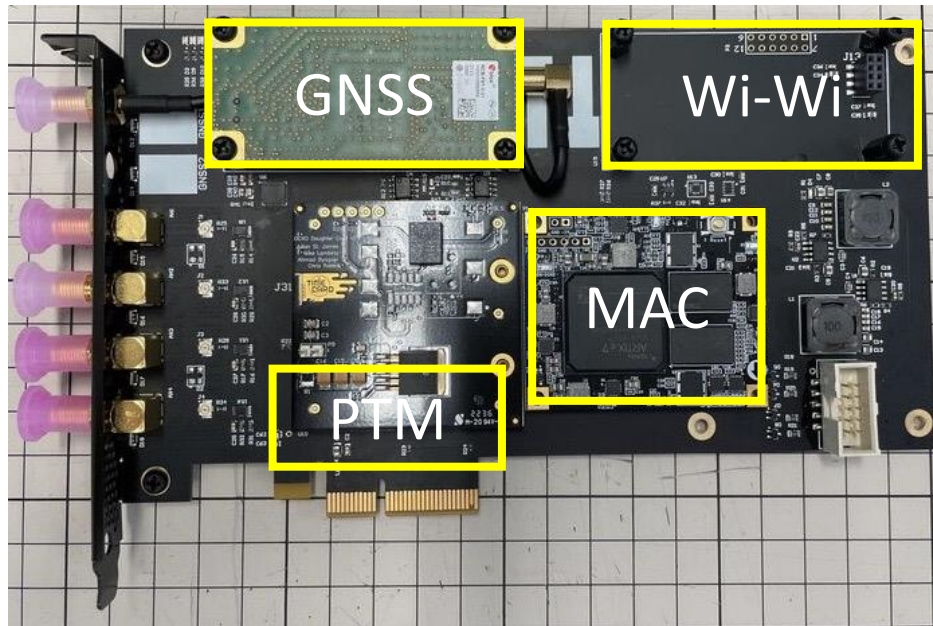
Time Error over 10 days



- pps-in comparison uses 120 Sample/sec (8ns resolution) and its resolution is visible on data.
- pps-in-out: **TE<16ns** over 10days.

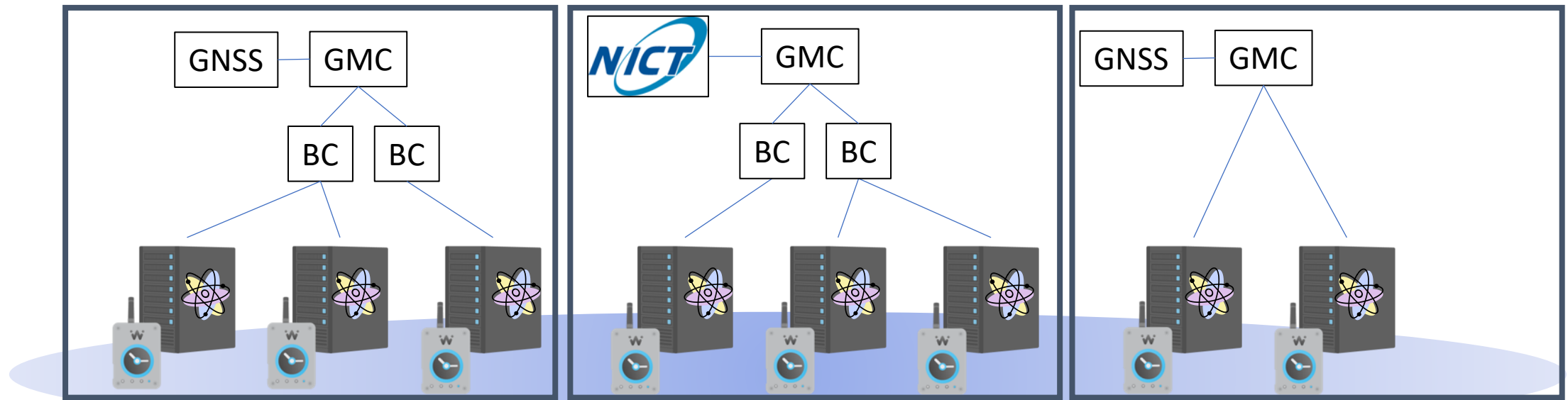


Time card in big picture



- Time Card is a timing controlling card that was developed by Meta through Open Compute Project (OCP) collaboration and used in Data Center.
- Time card compares various time source and generates integrated clock.

WiWi Resilient time network

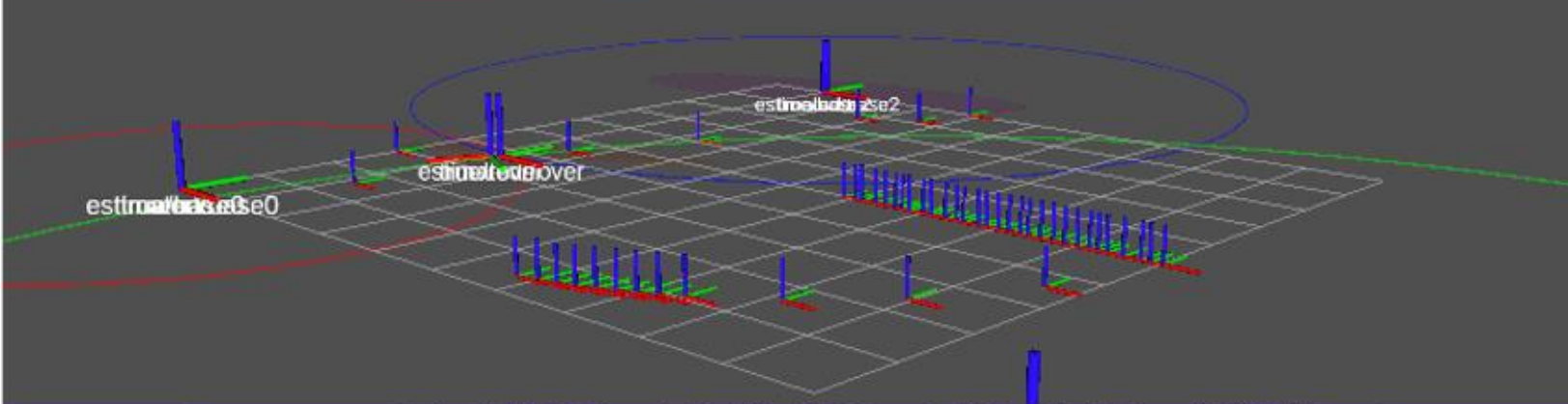
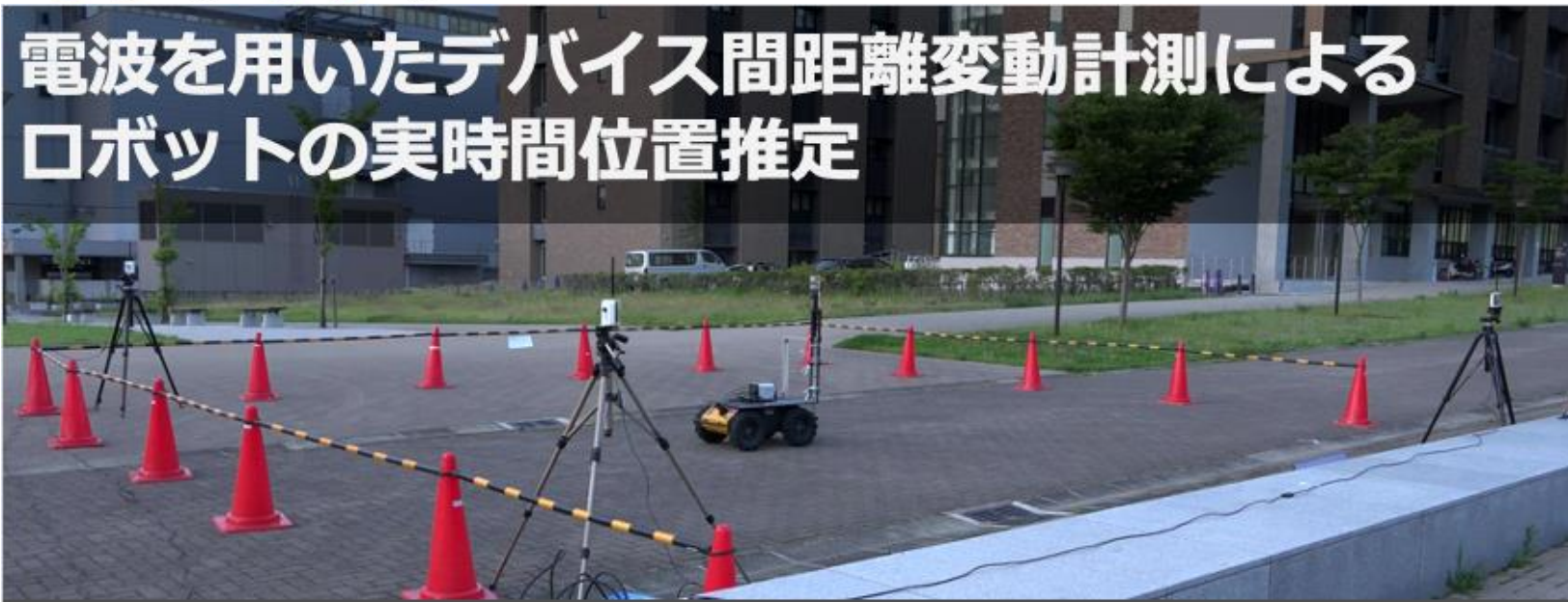


Wi-Wi over the air comparison
inter-connects different clock network

- Synchronization Over the air introduces another layer of resiliency.

Wi-Wi in Robotics

電波を用いたデバイス間距離変動計測による ロボットの実時間位置推定



- Real time positioning of a rover using wireless distance variation measurement
- presented at RSJ2021
- Authors: T. Nara, Y. Okada, S. Kojima, K. Takizawa, N. Shiga, S. Yasuda, K. Ohno, S. Tadokoro



TOHOKU
UNIVERSITY

- ○奈良貴明¹ 岡田佳都^{2,1} 小島匠太郎¹ 滝沢賢一³
- 志賀信泰³ 安田哲³ 大野和則^{1,2,se1} 田所諭¹

1: 東北大 2: 理研AIPセンター 3: 情報通信研究機構
RSJ2021-211-03



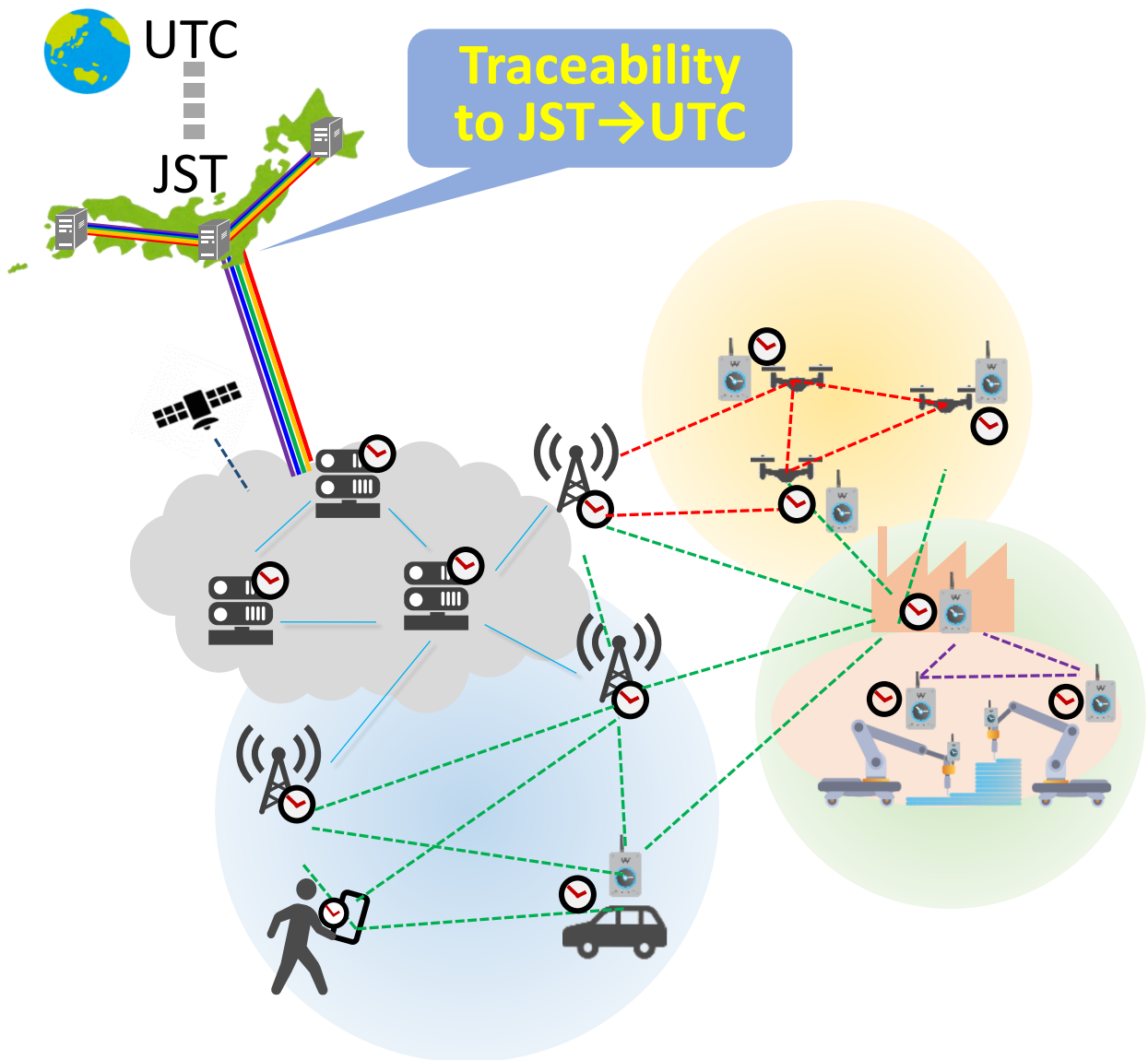
Graph optimization determines the position of Stationary Wi-Wi modules



*Video clip provided by T. Nara, U of Tohoku



Conclusion and Outlook



- PNT service in GNSS denied environment via Wi-Wi
- Local time scale traced to UTC
- Wi-Wi variation
 - 900MHz GFSK (module ready)
 - 2.4GHz Zigbee (demonstrated)
 - 2.4GHz Wi-Fi (module by OCP)
 - 900MHz LoRa (module by OCP)
- If we can help you, please contact Nobu:
shiga@nict.go.jp