



Space-Time Synchronization via Wireless Two-Way Interferometry (Wi-Wi)

2022/5/12

@ WSTS2022

National Institute of information and
communications technology (NICT)

Global alliance department

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WORKSHOP
ON
SYNCHRONIZATION
AND
TIMING SYSTEMS

MAY 9-12, 2022 | DENVER, CO



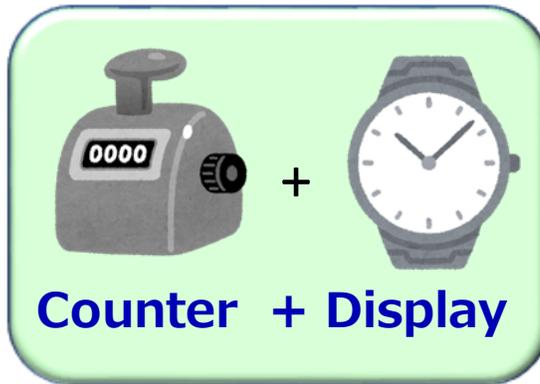
NICT generates Japan Standard Time (JST)



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Space-Time standards group

**Ultimate Oscillator
(Atomic clock)**

**Generation and
Dissemination of
JST**

Synchronization



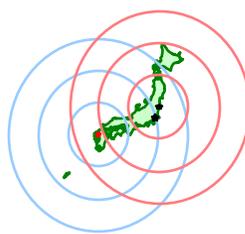
Cs Atomic clock



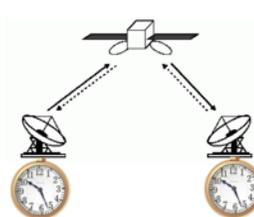
Sr Optical Atomic clock



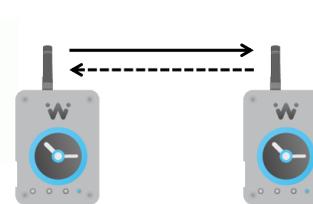
Generation of JST



Radio Clock



TWSTFT

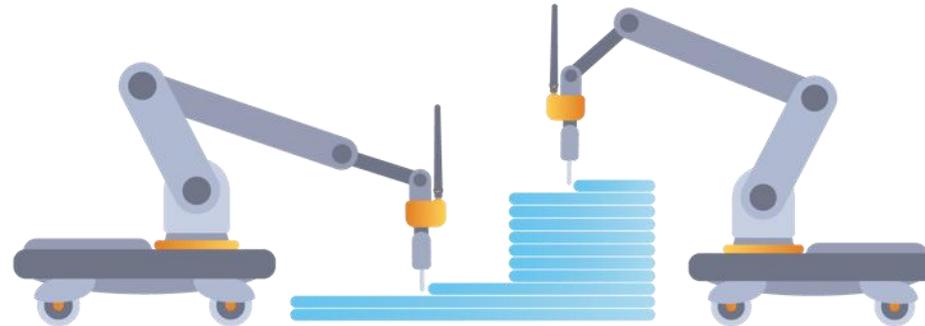
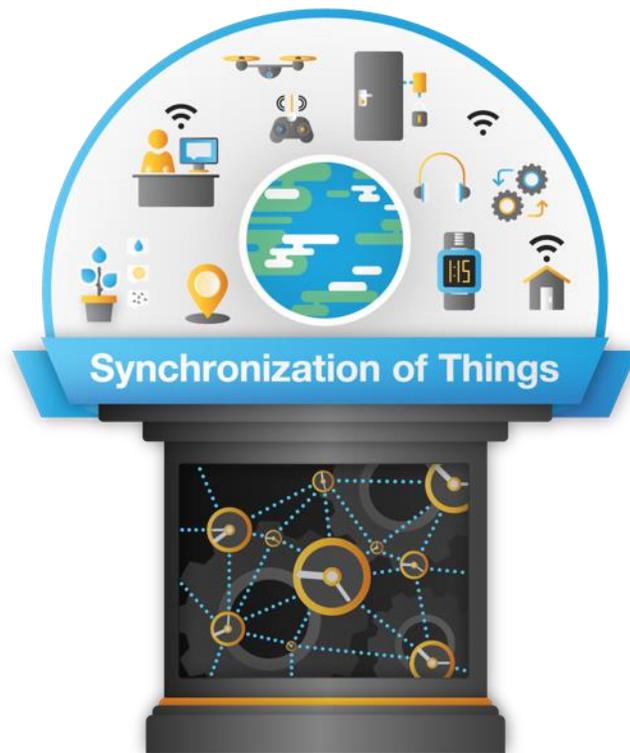


WiWi

Space-Time Synchronization

Our vision:

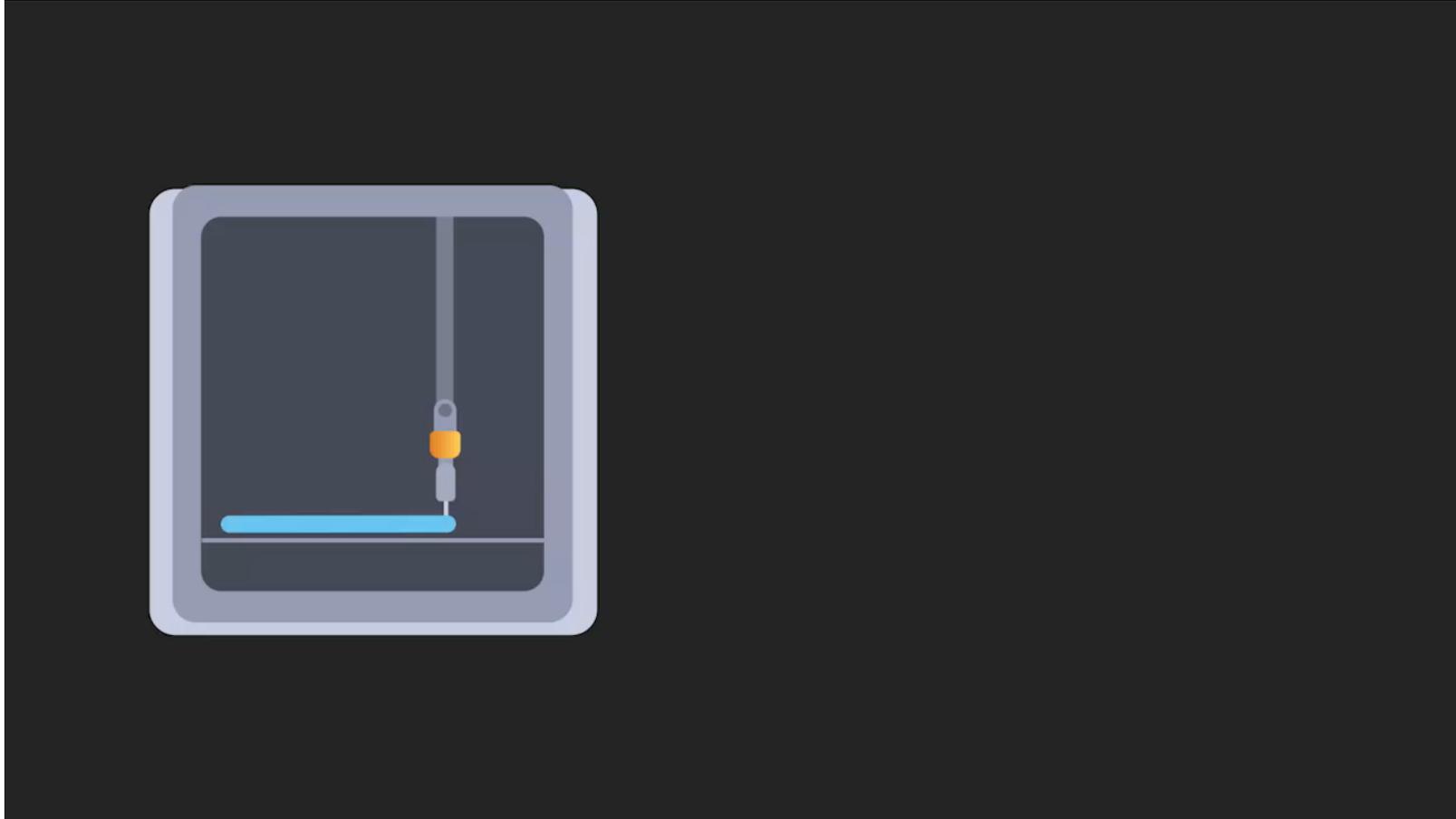
To establish an environment where precise **Space-Time synchronization** is readily available for **better human interaction**.



Space-Time Synchronization

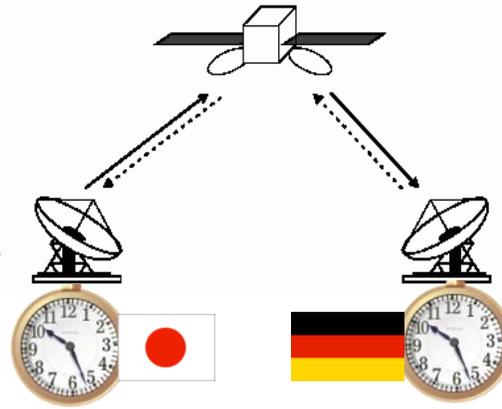
Allows all devices to share a universal clock via wireless communications.

wiwi Concept: Freedom to machines!



Pre-existing technology

Two-way satellite time and frequency transfer (TWSTFT)



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

$T_J - T_G$: Clock difference P : Propagation time

$\Delta T_G = (T_J - T_G) + P$: measurement at Germany

$\Delta T_J = (T_G - T_J) + P$: measurement at Japan

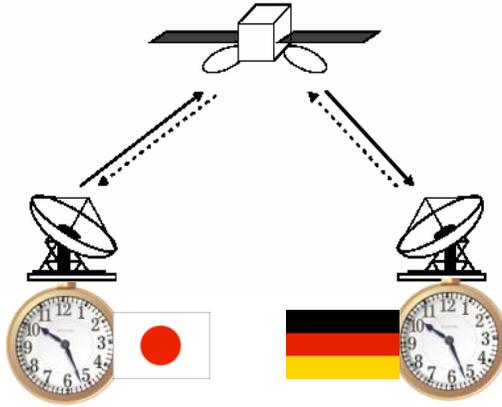
$P = (\Delta T_G + \Delta T_J) / 2$ (P = Sum of both meas.)

$T_J - T_G = (\Delta T_G - \Delta T_J) / 2$ ($T_J - T_G$ = Difference)

wiwi Wireless 2Way interferometry (Wi-Wi)

Pre-existing technology

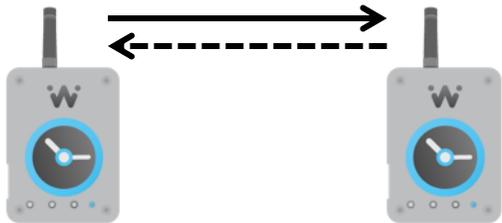
Two-way satellite time and frequency transfer (TWSTFT)



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

New!

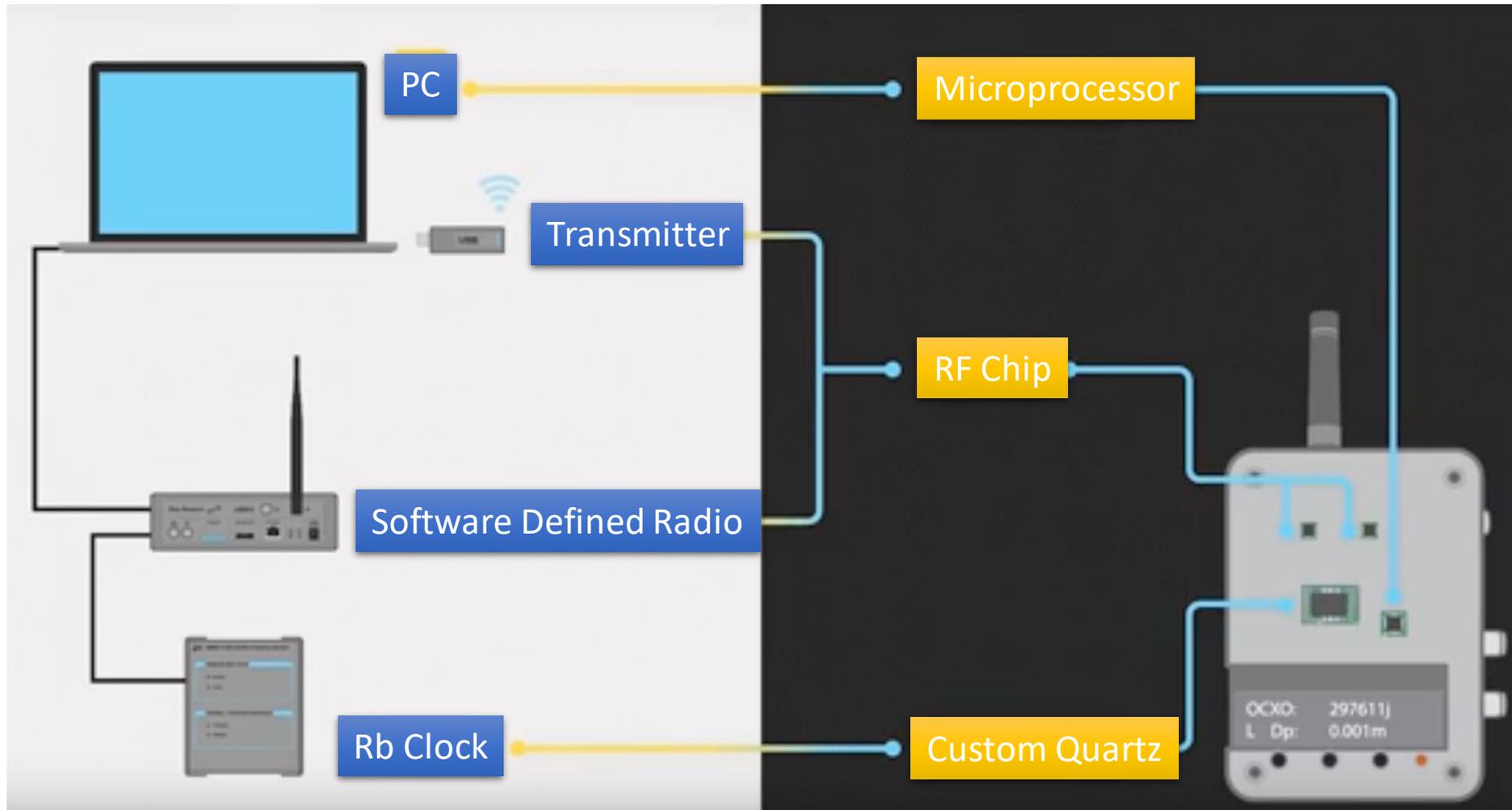
Wireless two-Way interferometry (Wi-Wi)



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.

Test system to module



Prototype modules



Satoshi Yasuda

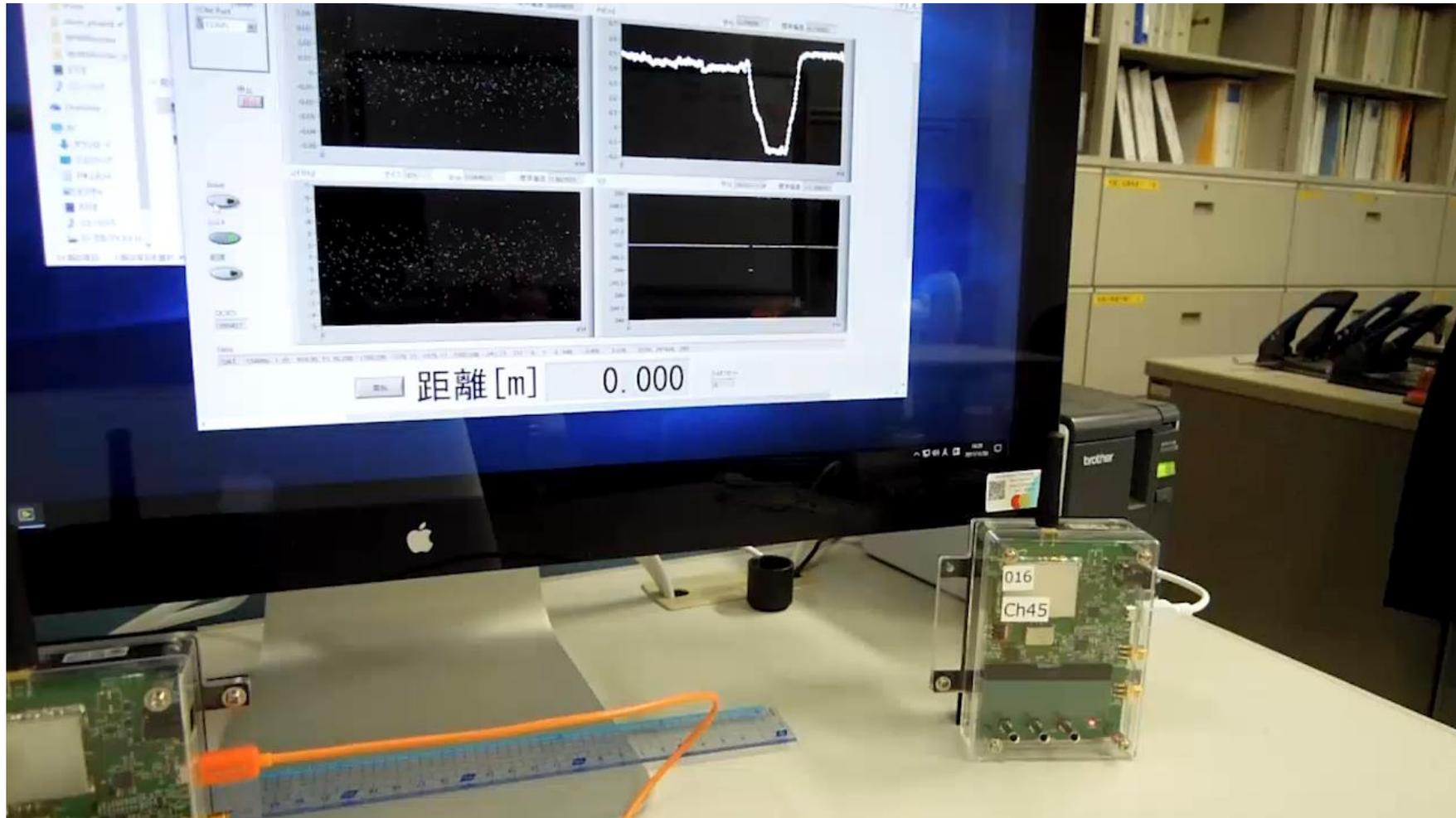
- 920MHz wireless communication module
- Fully compatible with IEEE 802.15.4
- Range 100m/5km(high power ver. best effort)
- Phase synchronization jitter: 20ps→16ps
- Time synchronization: 100ns→35ns



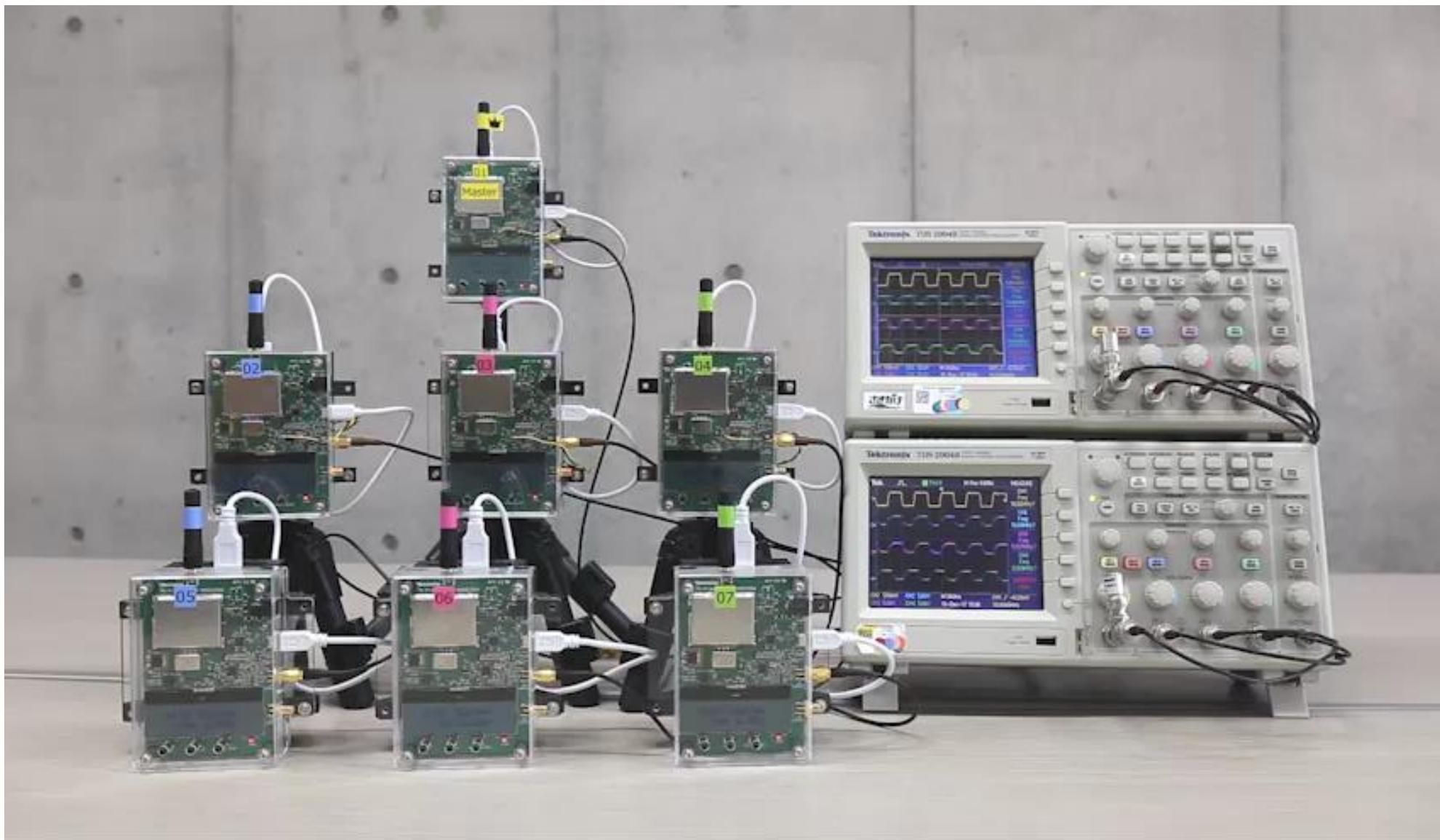
Demo of position variation

$$P = (\Delta T_G + \Delta T_J) / 2 \quad (P = \text{Sum of both meas.})$$

$$T_J - T_G = (\Delta T_G - \Delta T_J) / 2 \quad (T_J - T_G = \text{Difference})$$



7 modules synchronized

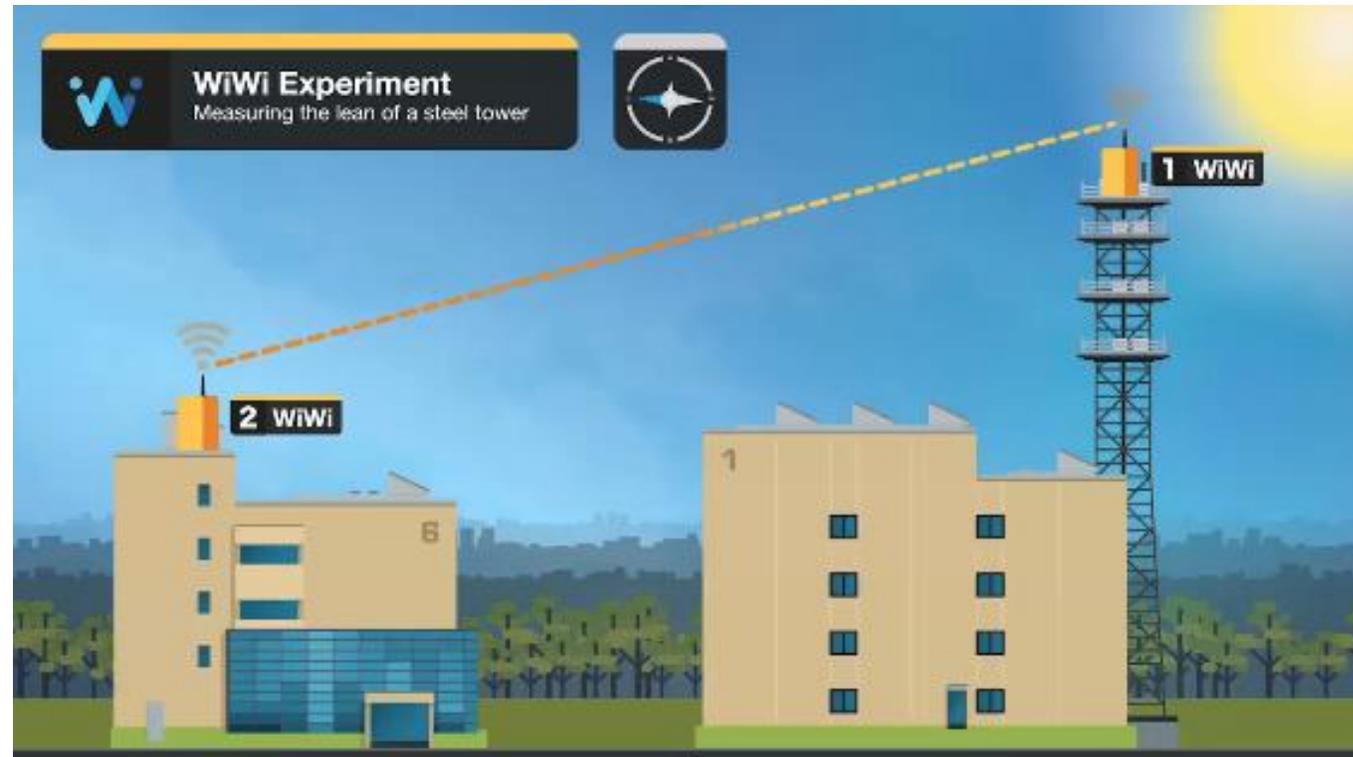
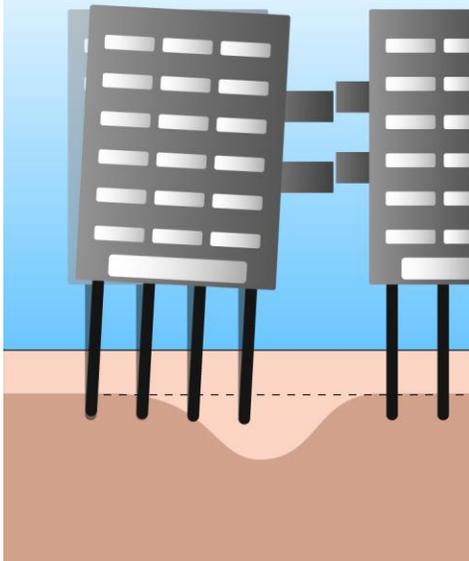




Application Example 1

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

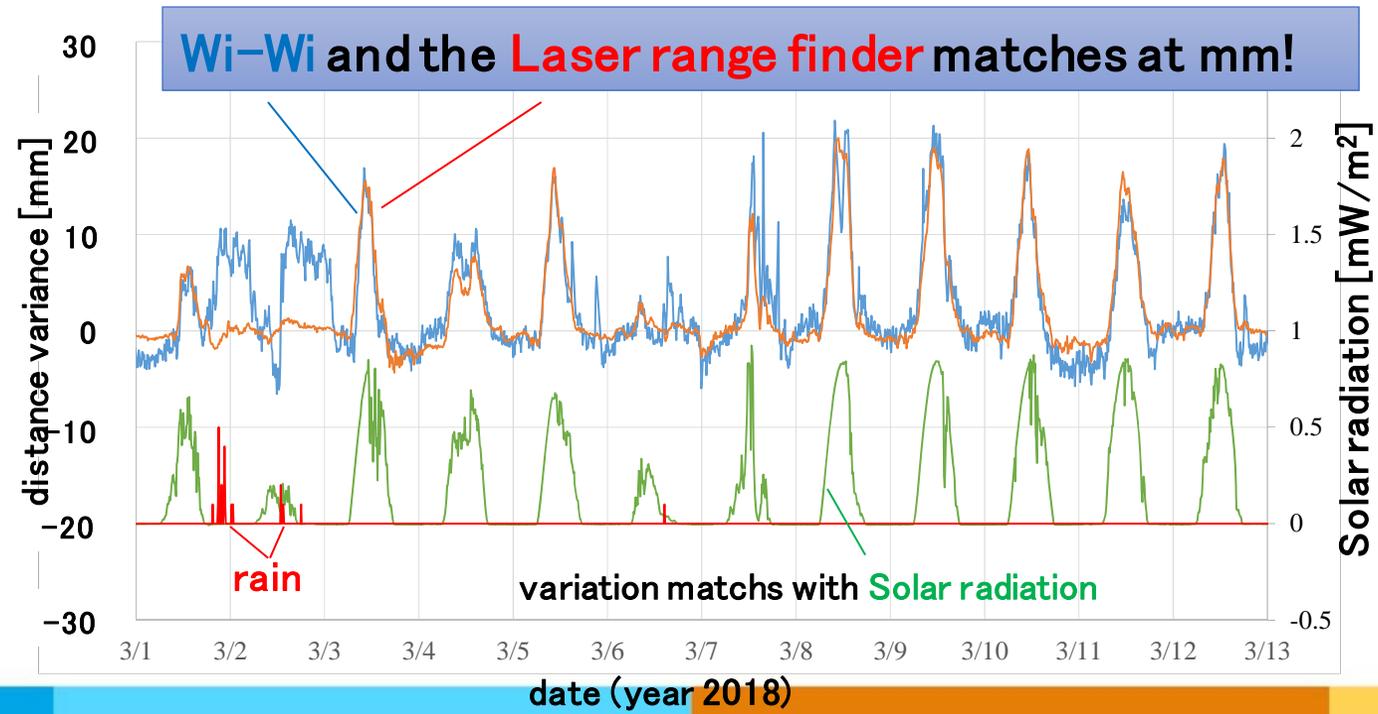
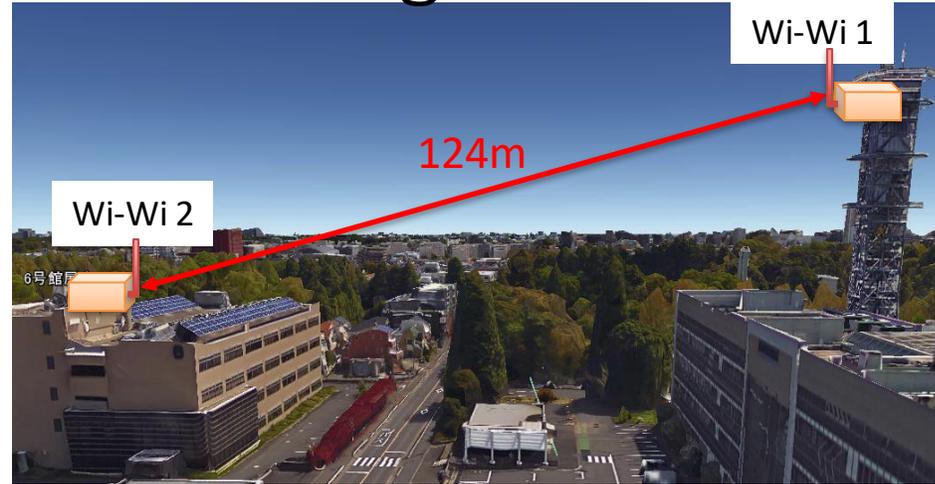
Cheap and **handy** system to monitor the distance variation at **1mm precision**



Example 1

Monitoring infrastructure

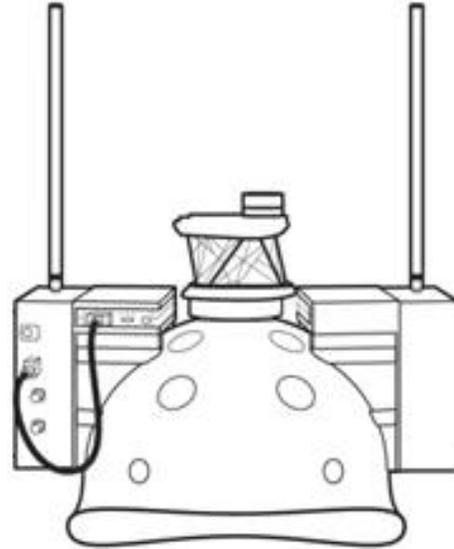
Wi-Wi system





Application Example 2

2D position variation

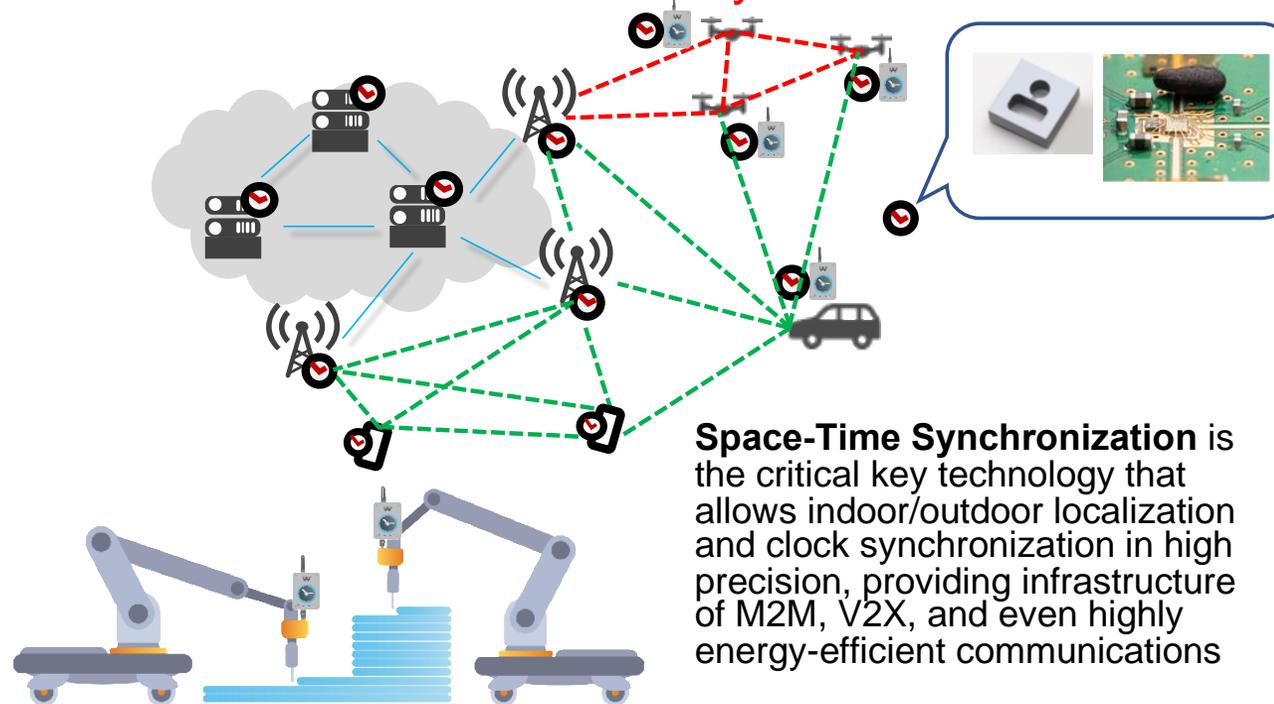


Standardization of Space-Time Synchronization

Space-Time Synch. (Wi-Wi) x Atomic clock chip + self clock-correction policy
=Decentralized synchronization with universal traceability

- ü Flexible
- ü Robust
- ü Reliable

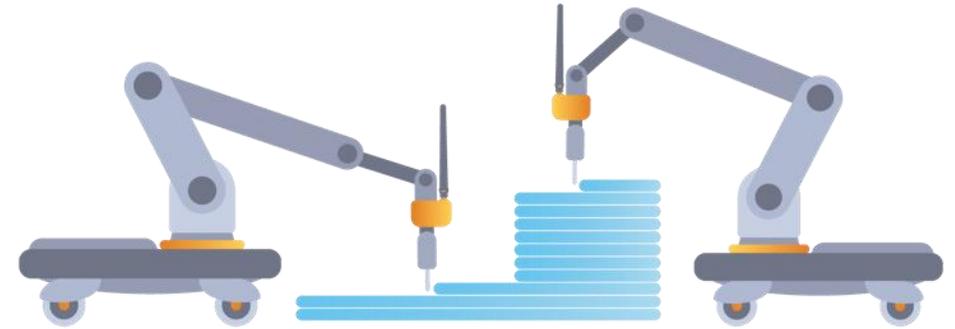
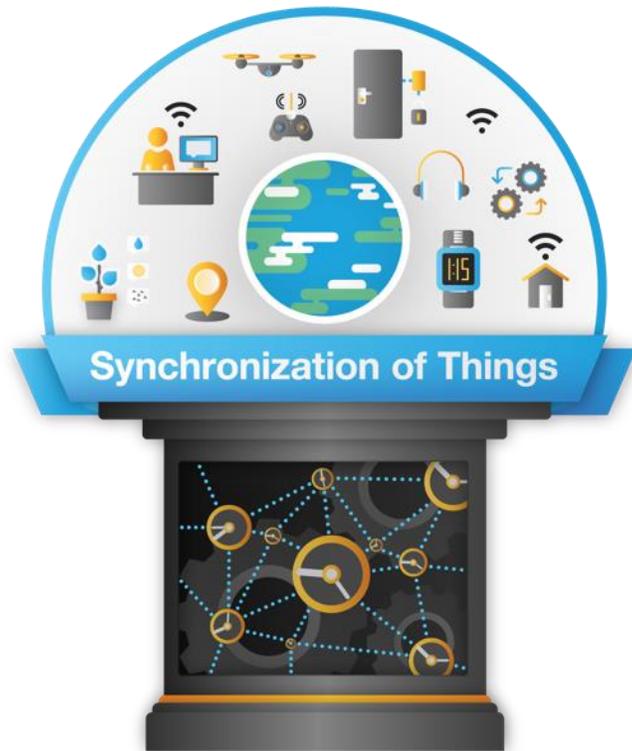
- ü Inclusive
- ü Resilient
- ü **Good stability**



- Input to **ITU-R WP5D** Future Technology Trend
- Join **3GPP** Rel-18 Study Item

Handy Synchronization

- Any wireless communication devices can be **precision synchronization devices**
...by small modifications.



Space-Time Synchronization

Allows all devices to share a universal clock via wireless communications and key to distributed collaboration of machines.

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If you live near Silicon valley or Tokyo, please visit us!