BATS for Smart Lampposts and 5G

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Smart Lampposts

- Key infrastructure of smart cities
- Equipped with networking interfaces, cameras and sensors
- Promote smart city innovations on a city scale
  - intelligent transportation
  - autonomous driving
  - real-time surveillance
  - high-speed WiFi coverage
- Estimated over 70 million smart lampposts will be installed worldwide by 2027
- Creating a global market of USD 8.3 billion

Smart Lamppost Connectivity

- Smart lampposts must be connected to the Internet backbone
- Possible technologies
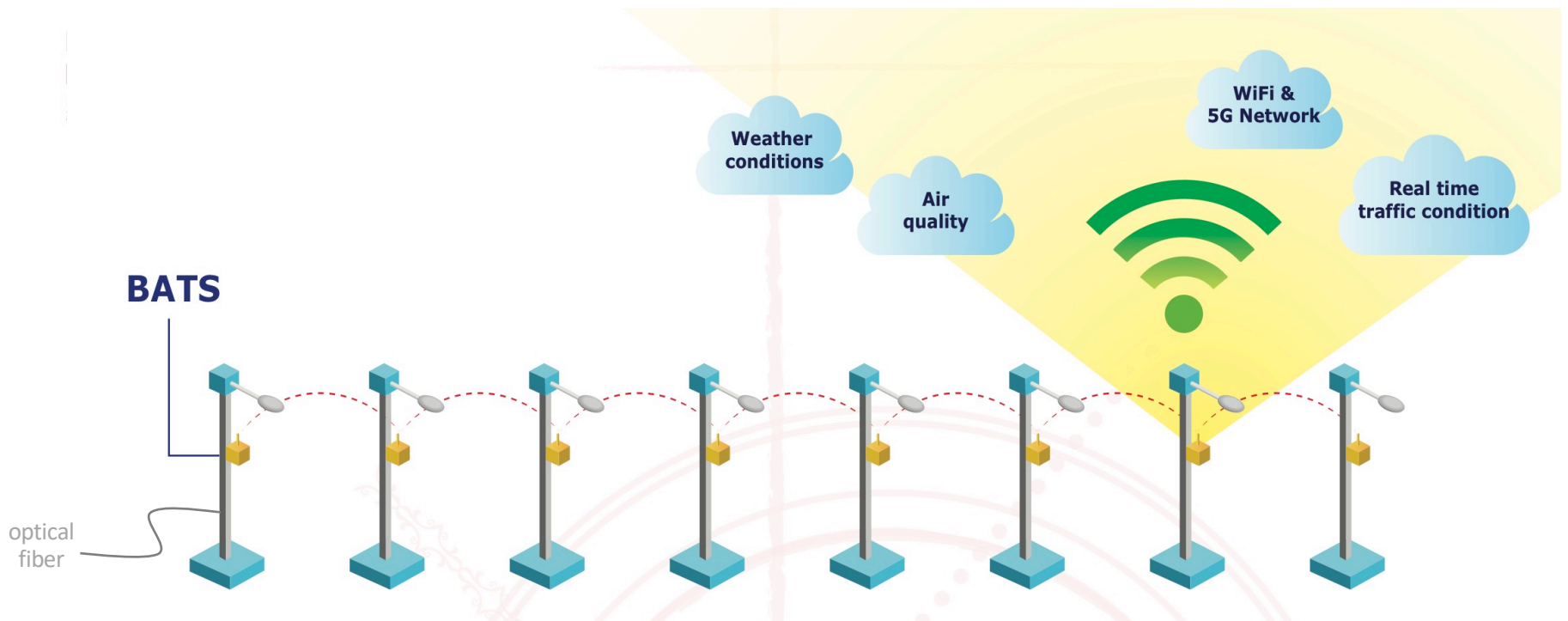 - optical fiber
  - 4G
  - BATS

Optical Fiber

- Pros
  - very high data rate
  - highly reliable
- Cons
  - high installation cost
  - very long setup time
  - very disrupting process
  - sometimes not possible
- Realistically only a small number of lampposts can be connected by optical fiber
- The rest still need to be connected to the Internet

How about 4G?

- A 4G card is installed at each lamppost
- Pros
  - easy to deploy
  - relatively inexpensive
- Cons
  - high recurrent cost
  - bandwidth drops drastically during rush hours

The Multi-hop Solution

Weather conditions

Air quality

WiFi & 5G Network

Real time traffic condition

BATS

optical fiber

Why BATS?

- Multi-hop is a longstanding problem in wireless communication
- Transmission can sustain no more than a few hops if data packets are treated as commodities
- The multi-hop curse
- **BATS** is an advanced network coding technology that can sustain tens or even hundreds of hops
- Recoding is employed at the intermediate nodes
- With **BATS**, a very long multi-hop network can be realized

BATS Codes
Theory and Practice

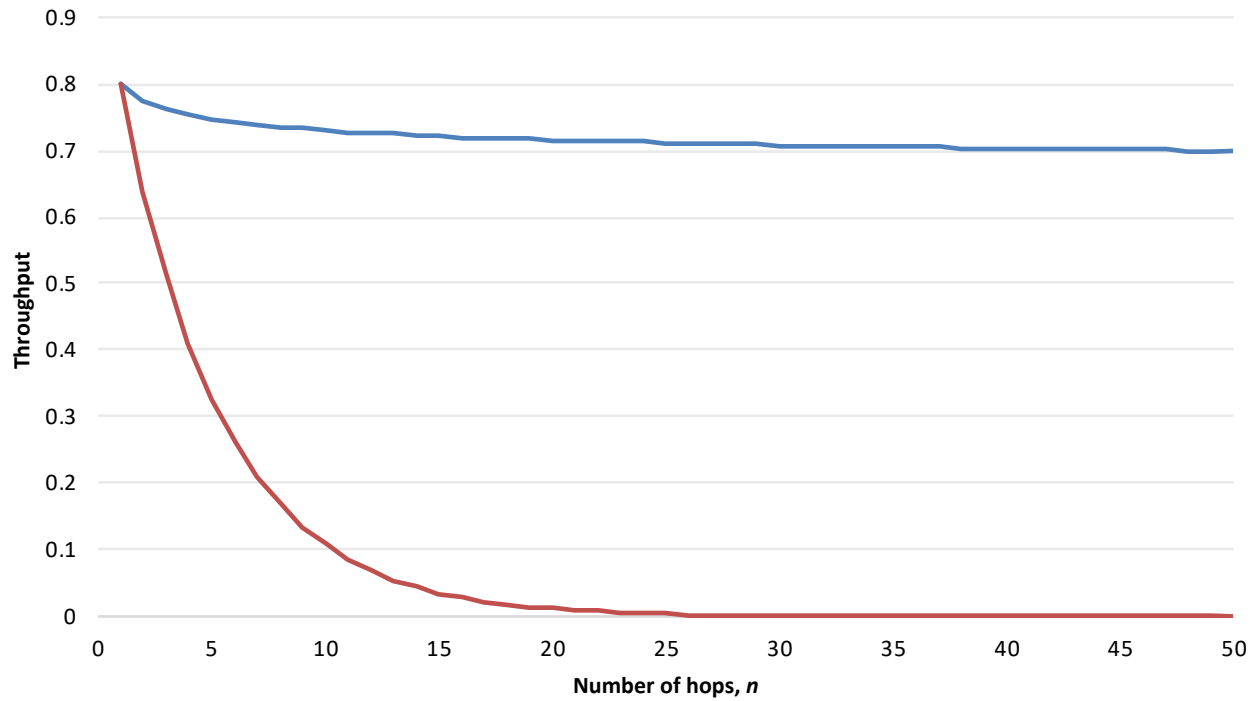**Shenghao Yang**
Raymond W. Yeung

BATS vs Routing

Advantages of BATS

high throughput ☑

low latency ☑

low coding complexity ☑

low storage requirement ☑

BATS vs 4G

- Low installation cost
- Easy to deploy
- Low recurrent cost
- Guaranteed bandwidth for essential data, e.g., post health check, video surveillance, etc
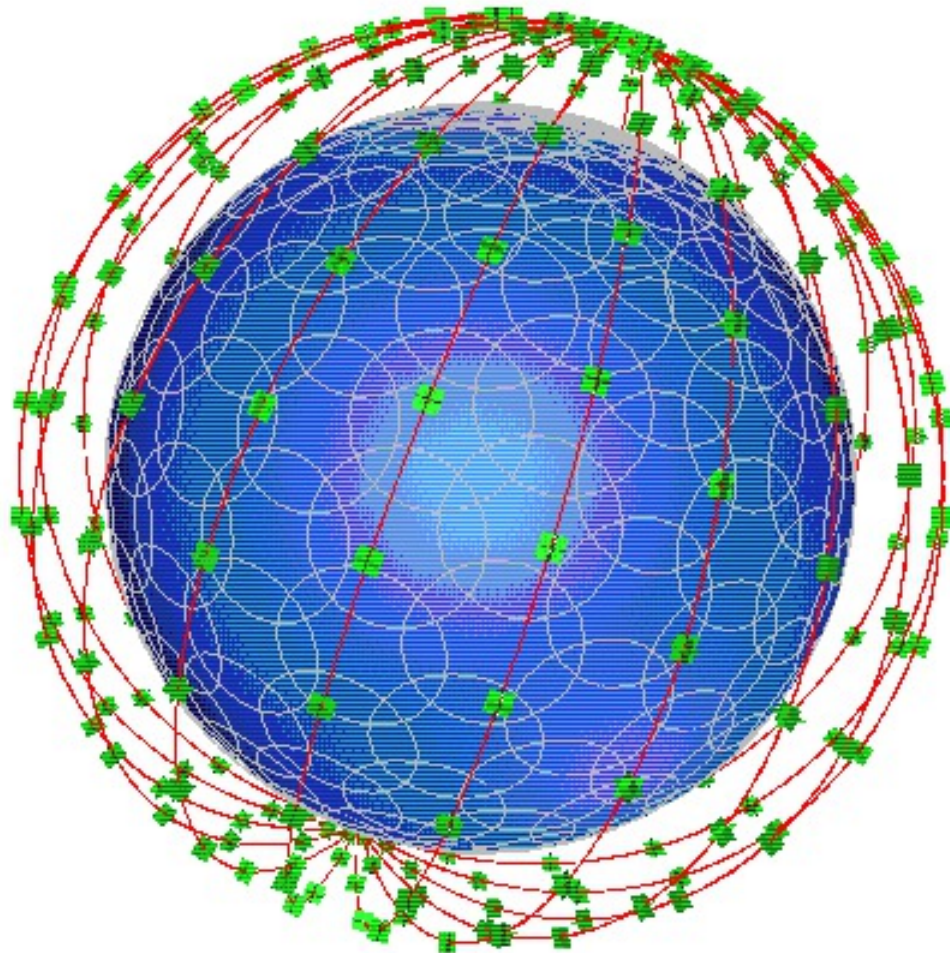- Can cover rural areas not reachable by fiber or 4G

Comparison with 4G

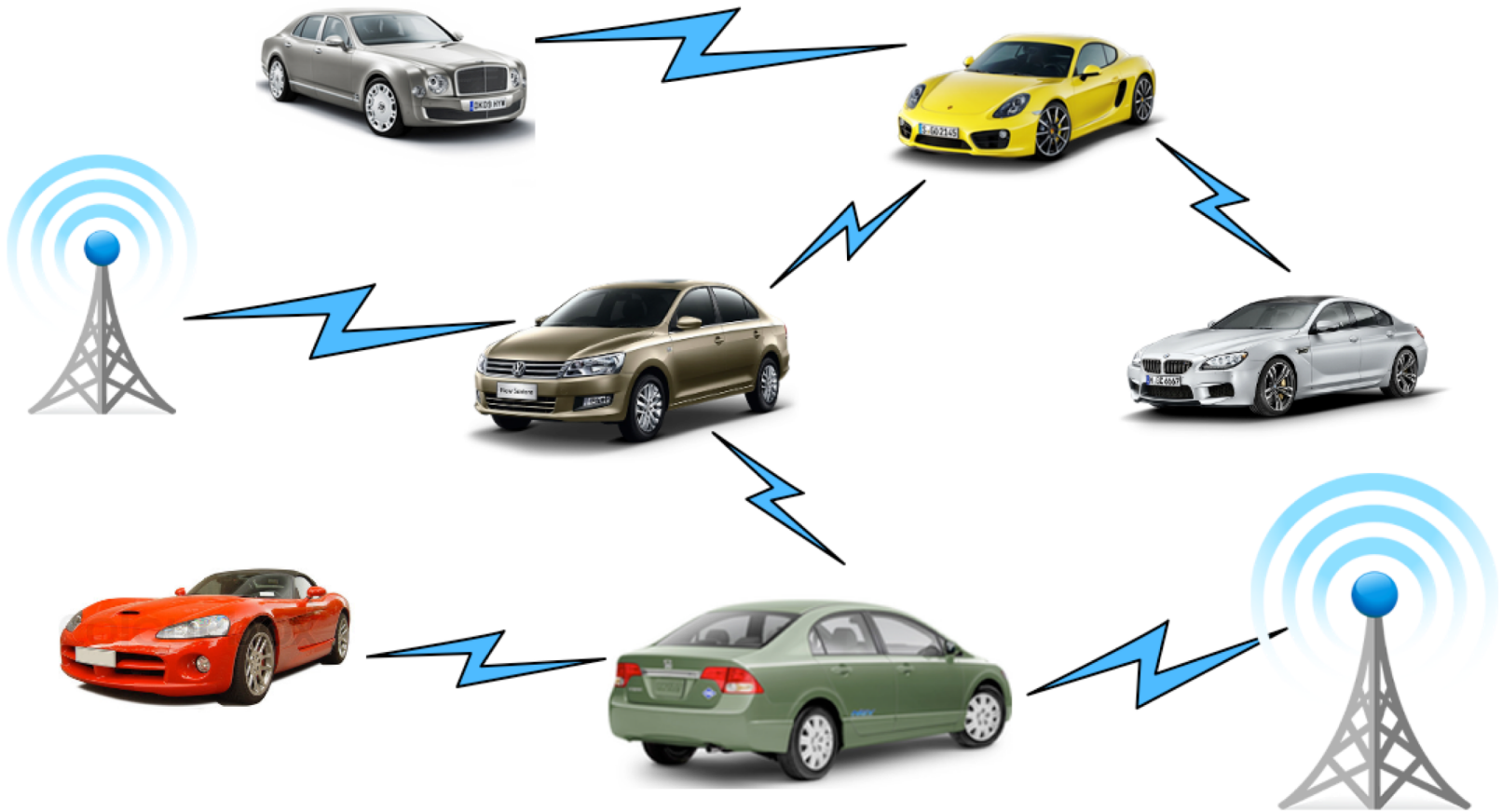|	Low installation cost	Easy to deploy	Low recurrent cost	Guaranteed bandwidth	Reach rural areas
4G	✓	✓			
BATS	✓	✓	✓	✓	✓

Other Applications of BATS

Wireless Ad Hoc Networks
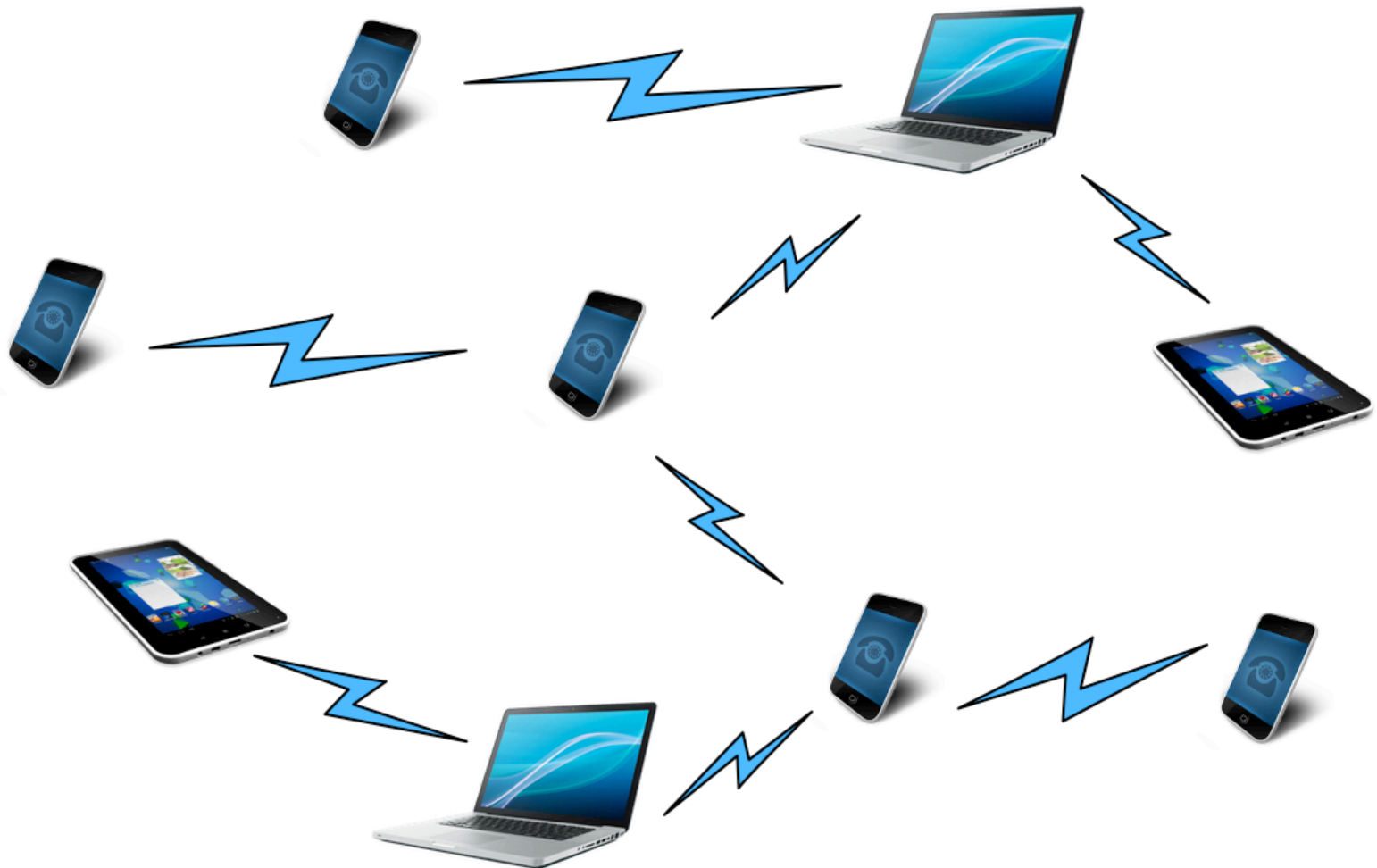
Satellite Networks

V2X

Underwater Acoustic Communication

Powerline Communication Networks

5G and Multi-hop

- Millimeter wave is used for transmission
- Receiver needs to be almost within line of sight
- Many base stations need to be deployed
- Relays also needed
- Many base stations and relays will be put on the smart lampposts
- How to connect the lampposts to the Internet?
- BATS provides a natural solution
- 3GPP has announced that multi-hop will be supported

Hong Kong Smart Lamppost Project

- Pilot
  - First phase: ~70 lampposts (mid-2019)
  - Second phase: 330 lamppost (2021/22)
- Massive deployment: 70,000 lampposts
- INC has been engaged in this pilot project to apply BATS code

Internet Draft Submitted

BATS Coding Scheme for Multi-hop Data Transport

draft-yang-nwcrg-bats-00 (Oct 21, 2018)

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The BATS solution