

# Update of the Deployment of BATS Code

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n-hop technologies  
Hong Kong



# Smart Lamppost Connectivity

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

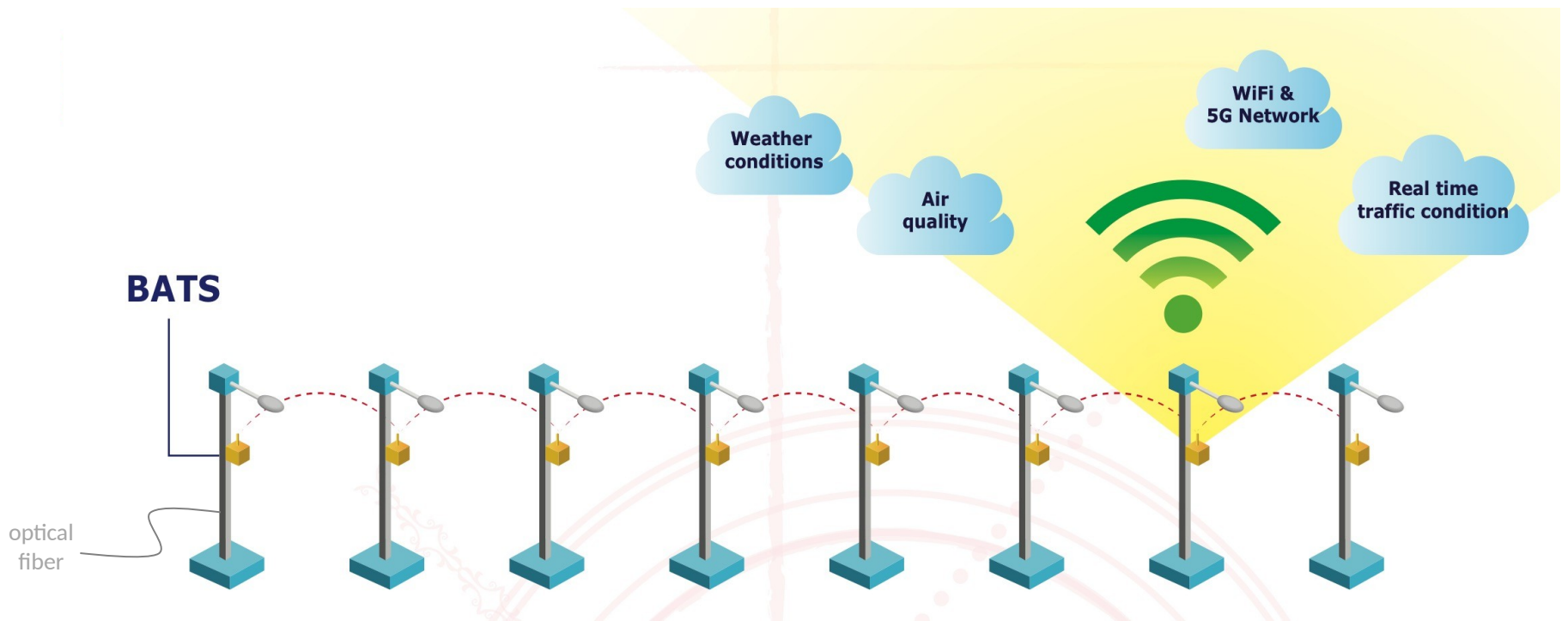
# Optical Fiber

- 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

# BATS: The Multi-hop Solution



# 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, without relying on link-by-link retransmission (very bad for video transmission)
- Recoding is employed at the intermediate nodes
- With **BATS**, a very long multi-hop network can be realized



MORGAN & CLAYPOOL PUBLISHERS

# BATS Codes

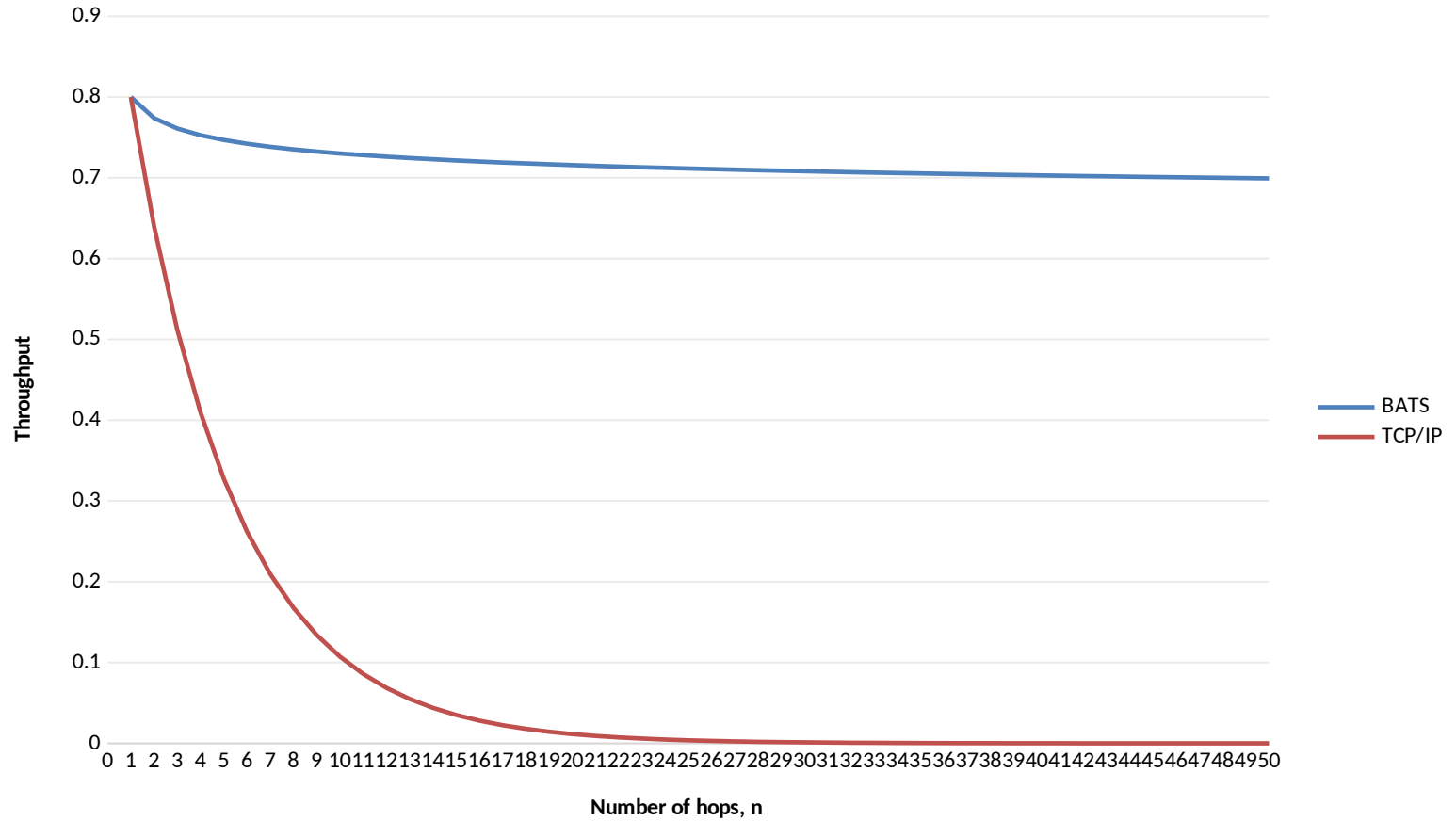
*Theory and Practice*

Shenghao Yang  
Raymond W. Yeung

*SYNTHESIS LECTURES ON  
COMMUNICATION NETWORKS*

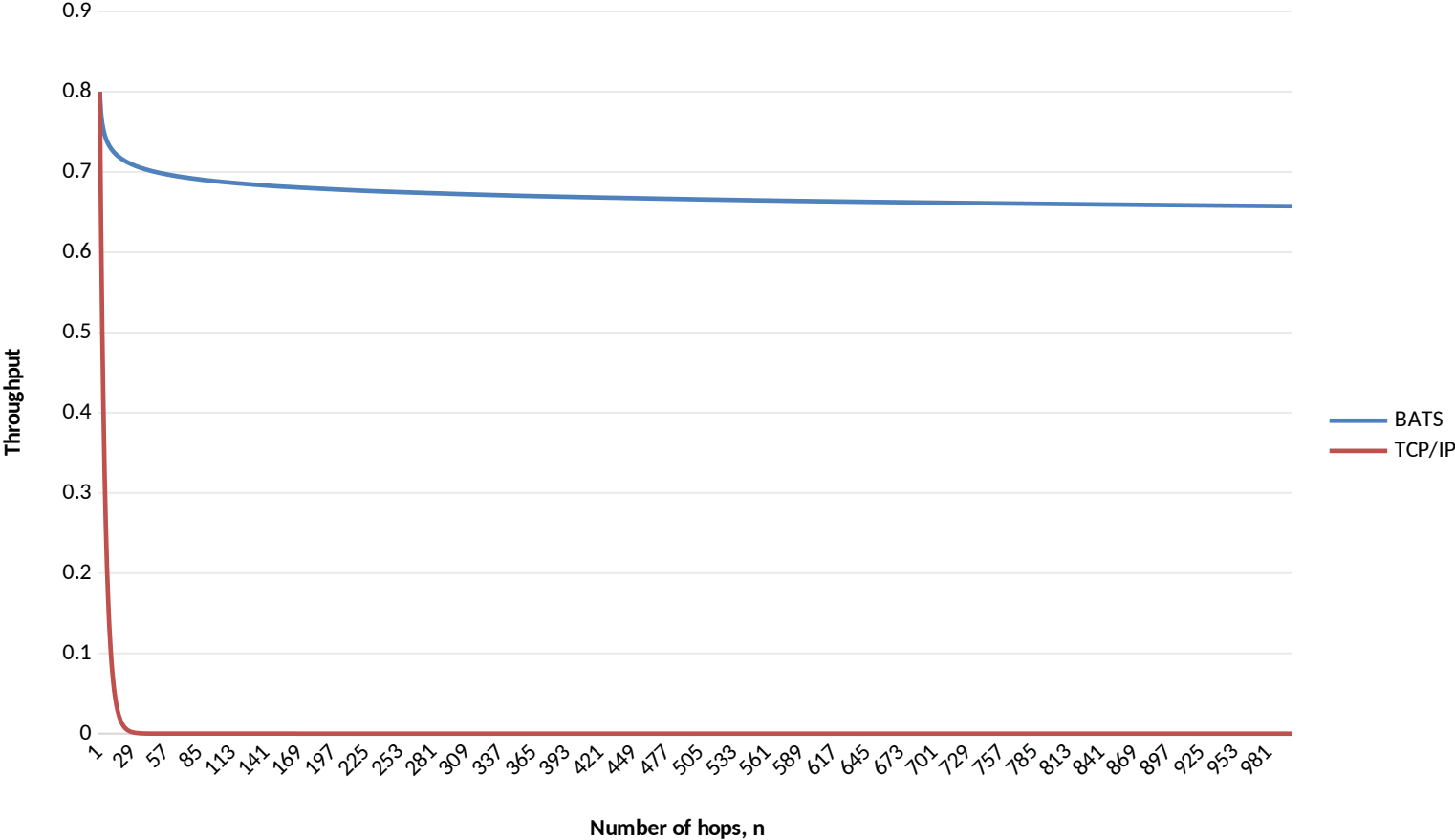
R. Srikant, *Series Editor*

# Performance Comparison





# Performance Comparison



# Technical Features

high throughput ○

low latency ○

low coding complexity ○

low storage requirement ○

# Hong Kong Smart Lamppost Project

# Pilot Project

- Installation of 400 smart lampposts starting summer 2019
- Followed by several 10,000 lampposts
- [n-hop](#) has been commissioned to deploy BATS in 36 out of the first 50 smart lampposts



## 目標安裝約400支 港產智慧燈柱 收集城市數據

▲智慧燈柱外觀的顏色能夠轉換，配合不同地區主題。

【本報記者徐穎軒報導】推動智慧城市發展，香港政府計劃，九龍灣及觀塘先裝52枝智慧燈柱，集定位、收集城市數據、Wi-Fi及5G基站多功能於一身，到今年年中陸續啟用。助政府的智慧城市管理，預計目標設置400枝智慧燈柱，讓數碼安全城市發展及探測，預計計劃開支2.72億元。

**今年陸續啟用 加強城市管理**

另外，「數碼個人身份(eID)」亦將於2020年推出，屆時市民只需2個步驟申請，就可利用eID在政府各項服務，包括查詢車牌、繳稅、登記車輛等。

**智慧燈柱部分功能及應用**

集定位、又稱燈柱內不少技術，均為本地中小企及大學研發，形燈柱並非於外購買一快燈柱，而是「自己造」。

**eID明年推 可登入政府服務**

另外，政府計劃在2020年推出「數碼個人身份」，目前仍在開發階段，資料將由明日起示範如何申請及使用eID，詳情請向「數碼個人身份」查詢。

**明年可用eID登入政府服務**

另外，政府計劃在2020年推「數碼個人身份(eID)」，目前仍在開發階段，資料將由明日起示範如何申請及使用eID，詳情請向「數碼個人身份」查詢。

**明起展示縮小版**

資料將由明日起至16日，於觀塘區議會展覽廳展示縮小版智慧燈柱，現場亦有智慧燈柱、城市數據等示範。







- Participated in the 47th International Exhibition of Inventions of Geneva, 2019:  
“Wireless Multi-hop Network for Smart Lampposts”
- Awarded a Gold Medal with Congratulations of the Jury



# DIPLÔME

**Inventions**  
Geneva

**SALON  
INTERNATIONAL  
DES INVENTIONS  
GENÈVE**

Après examen, le Jury International a décidé

de remettre à: Shenghao Yang, Raymond W. Yeung, Raymond Chan Kwong Wing

pour l'invention: BATS, technologie sans fil capable d'offrir aux lampadaires intelligents une connectivité Internet à large bande passante sans avoir à poser de nouvelles fibres optiques.



MÉDAILLE D'OR  
GOLD MEDAL  
GOLDMEDAILLE

Genève, le 12 avril 2019

Avec les félicitations du jury  
With the congratulations of the jury  
Mit höchsten Empfehlungen des Preisgerichtes

Le Président du Jury: David Tajj

Le Président du Salon: Jean-Luc Vincent

co-developed with



Photo for reference only

### ***BATS box specification***

Inter-pole communication:

Support max 120Mbps inter-pole communication at max distance 120m.

Dimension: 230 x 100 x 90mm (box)  
103 x 83 x 35mm (external antenna)  
Weight: 3kg  
Interface type: 1x 10/100/1000 Ethernet (RJ45)  
1x USB 2.0  
1x USB 3.0

Power requirement: 24V DC, max 1.5A  
Power LED: Yes

Operating temperature: -40°C to 70°C  
Storage temperature: -40°C to 85°C  
Operating humidity: 5-95% @40 °C non-condensing

Ingress protection: IP65

Antenna Type: 2 pieces of MIMO directional antennas  
Antenna Gain: 11dBi  
Max transmitted power: 500mW each antenna

Supported protocol: TCP, UDP, IP

CPU: Intel® Atom E3950™ quad-core processor,  
TPD 12W  
RAM: on board 4G memory, DDR3L 1855MHz  
SSD: 120G

# Current Status

- Successfully deployed at two streets
  - one street heavily vandalized during a protest on 8/24
- Almost done at another street
- The general public has concern about the installation of video cameras on the lampposts due to possible infringement of privacy
- The Government has formed a special committee to review the smart lampposts applications
- One possible recommendation is to replace the cameras by radars or lidars



# BATS + Fog Computing

- BATS is inherently a fog computing application because the computation must be done at the edge
- Plan to install 20 fog computing based smart lampposts on the CUHK campus, with BATS being provided as a service by the fog node
- A prototype for next generation smart lampposts

# Further Opportunities

- The HK Government is interested in installing smart lampposts in the country parks (largely not covered by cellular) for providing WiFi services to hikers
- Many cities in Southeast Asia are interested in pilot smart lamppost projects

# Internet Draft Submitted

BATS Coding Scheme for Multi-hop Data Transport  
draft-yang-nwcrg-bats-00 (Oct 21, 2018)

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# BATS IPs

- 3 US patents
  - US Patent No. 8,693,501
  - US Patent Application No. 14/871,257
  - US Patent No. 10,237,782
- 6 EU patents
  - DE validation of EP Patent No. 2644004
  - FI validation of EP Patent No. 2644004
  - FR validation of EP Patent No. 2644004
  - GB validation of EP Patent No. 2644004
  - SE validation of EP Patent No. 2644004
- 2 China patents
  - CN Patent No. ZL 201180055775.3
  - CN Patent Application no. 201610857698.8

# The BATS solution

