Update of the Deployment of BATS Code

Raymond W. Yeung

Institute of Network Coding
The Chinese University of Hong Kong

n-hop technologies
Hong Kong

Smart Lamppost Connectivity

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

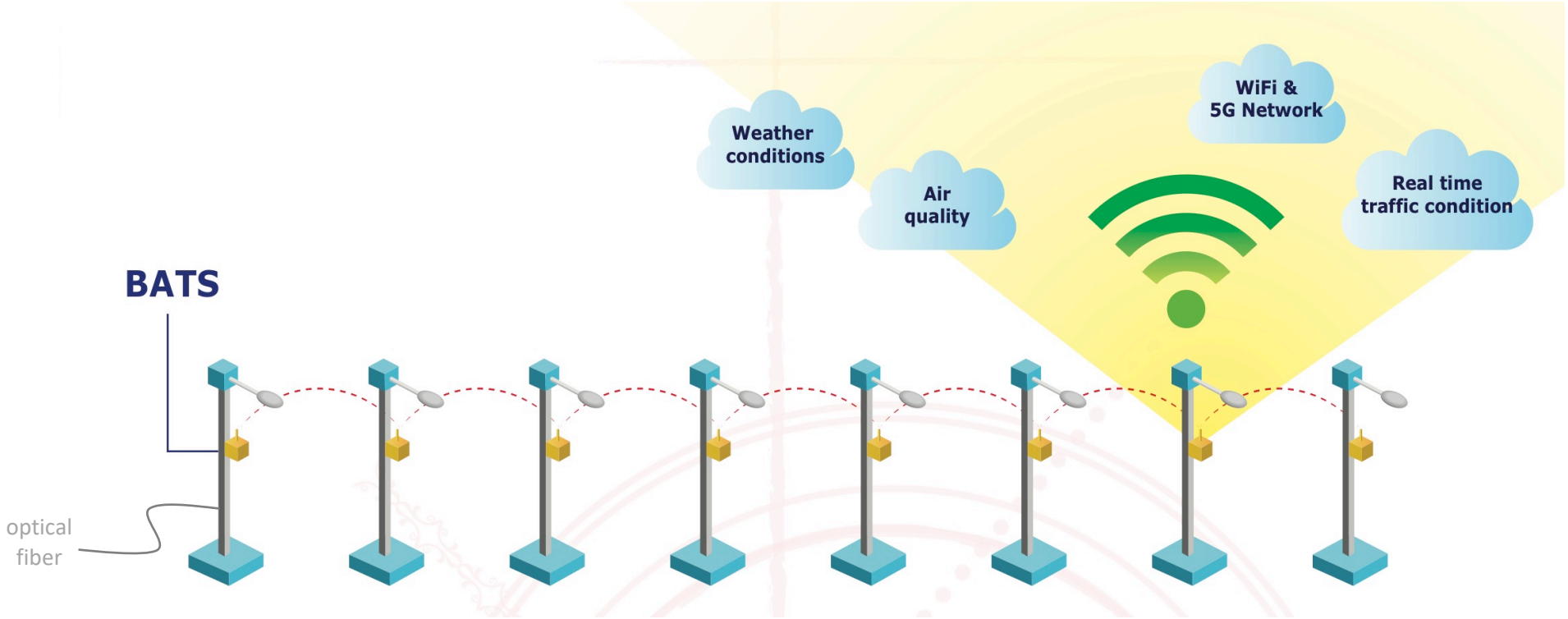
Optical Fiber

- 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?

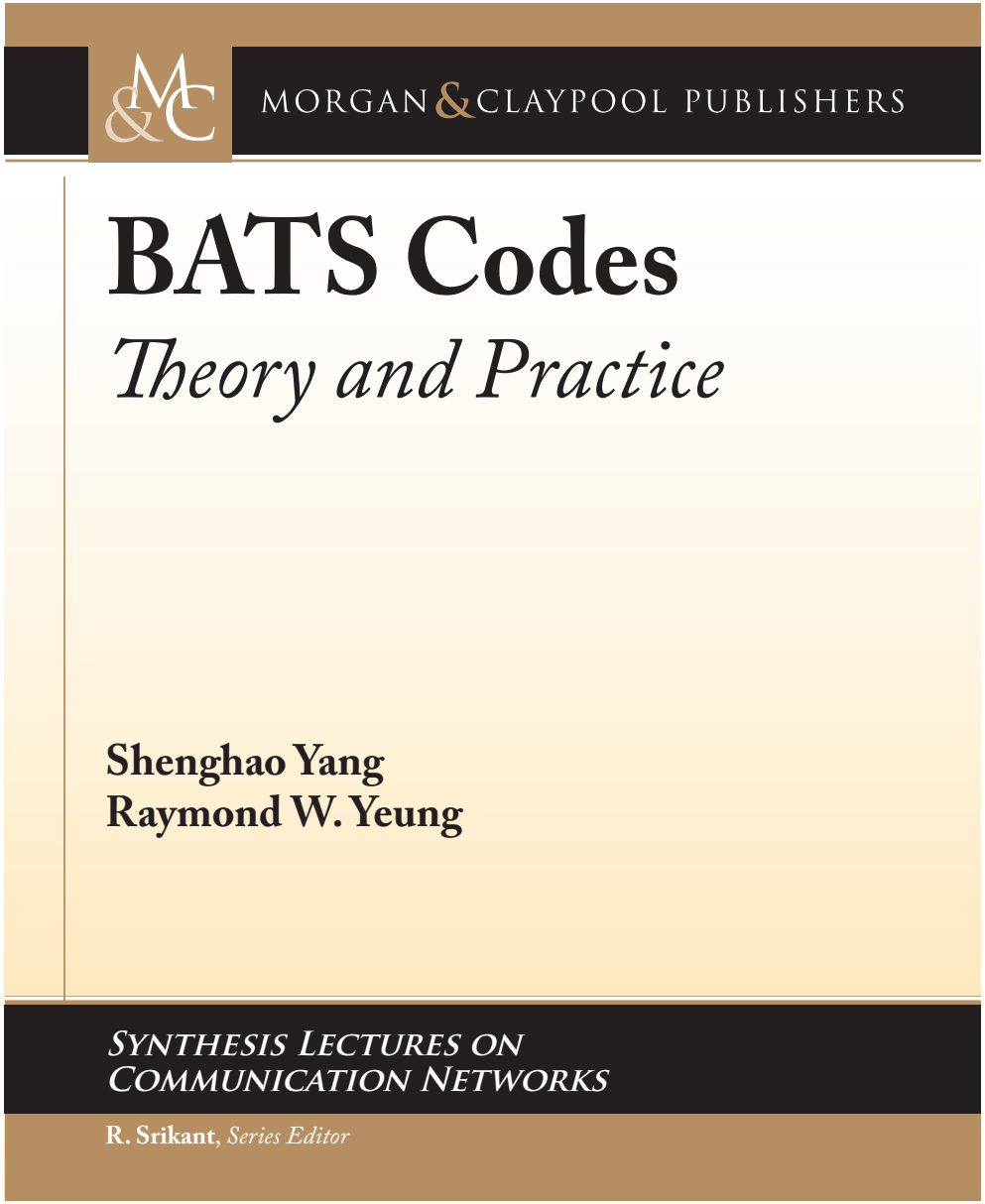
- A 4G card is installed at each lamppost
- Pros
  - easy to deploy
  - relatively inexpensive
- Cons
  - high recurrent cost
  - bandwidth drops drastically during rush hours

BATS: The Multi-hop Solution

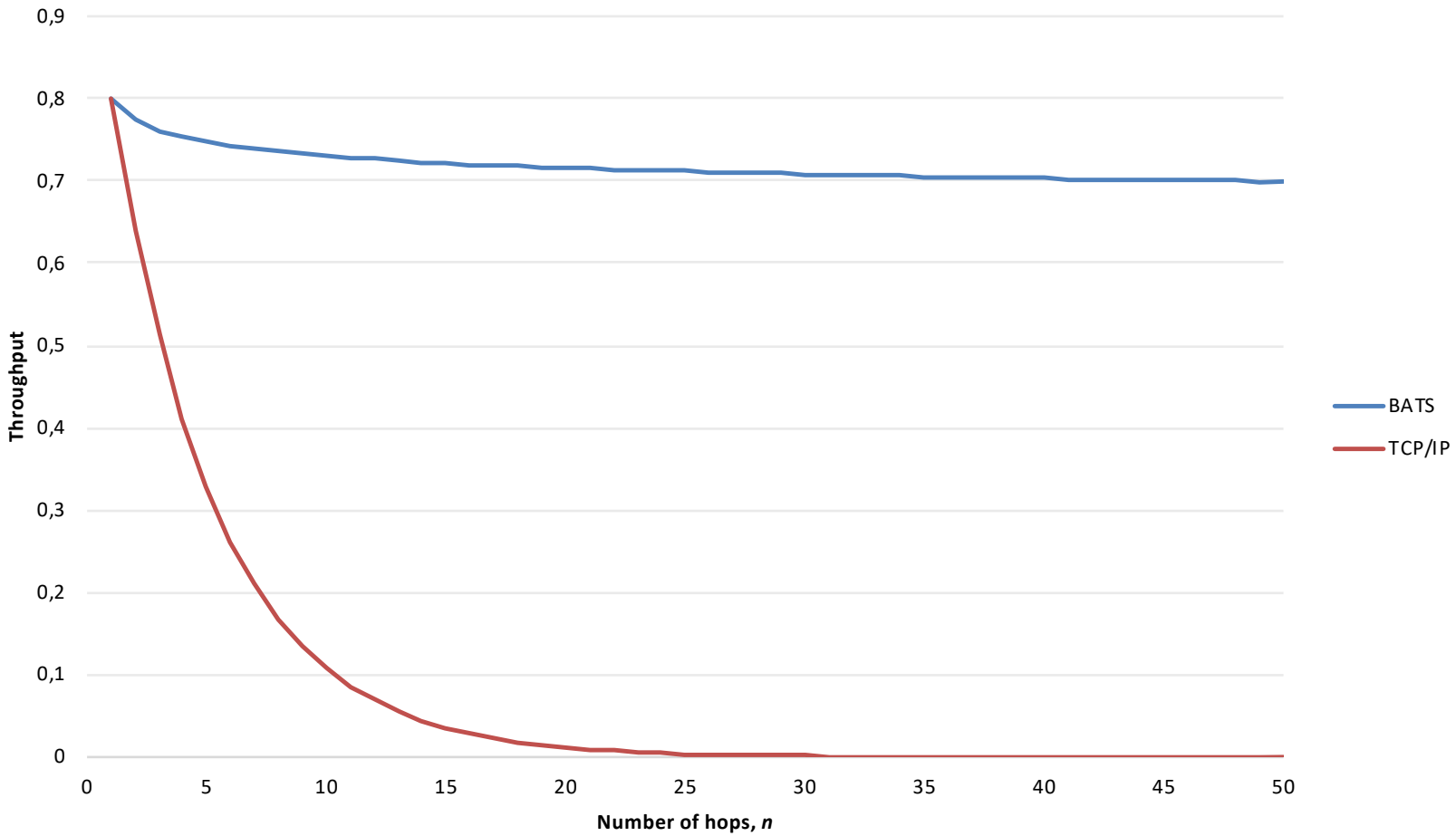


Why BATS?

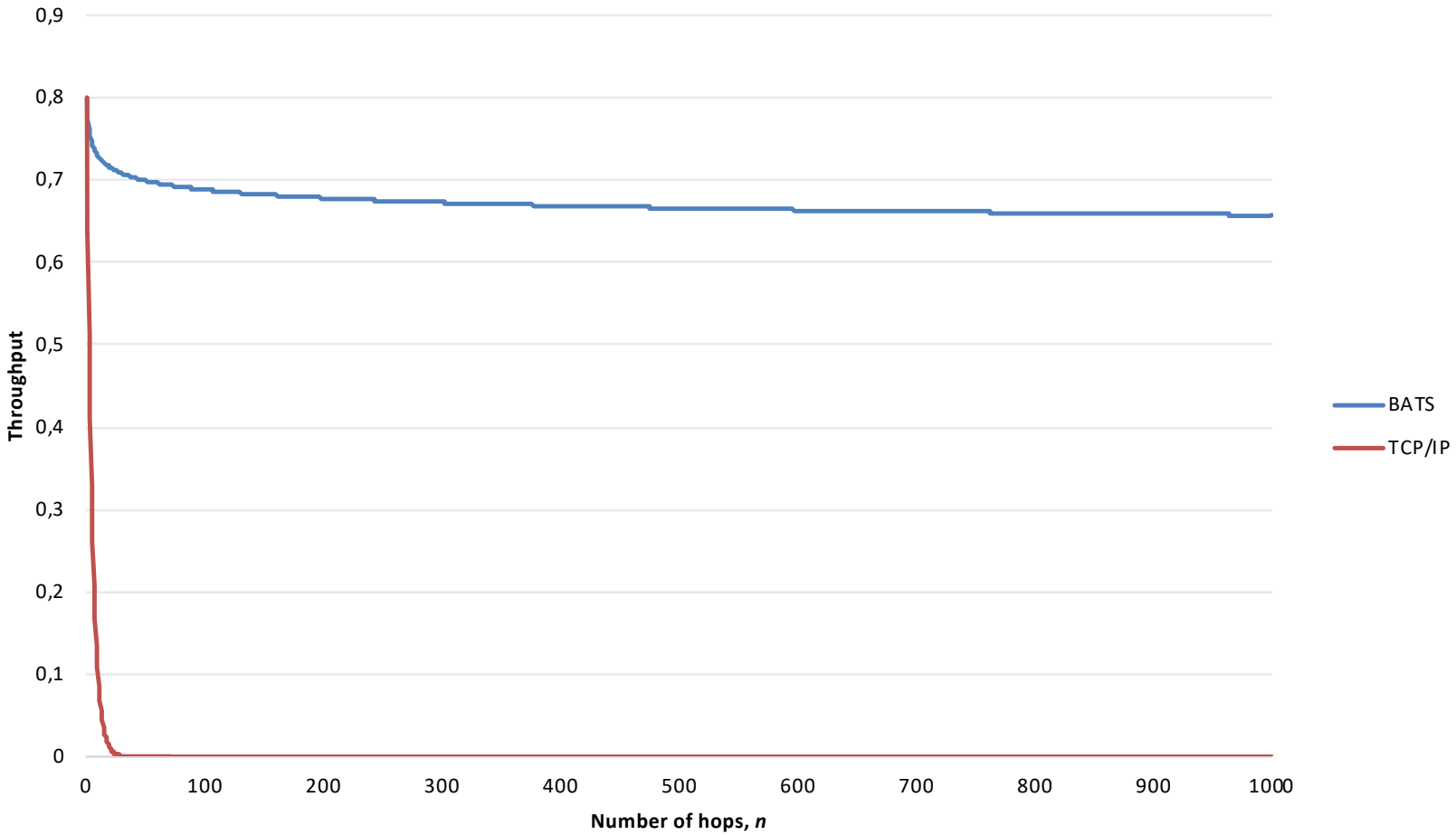
- Multi-hop is a longstanding problem in wireless communication
- Transmission can sustain no more than a few hops if data packets are treated as commodities
- The multi-hop curse
- **BATS** is an advanced network coding technology that can sustain tens or even hundreds of hops, without relying on link-by-link 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

52枝智慧燈柱 觀塘九龍灣率先裝

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明年可用eID登入政府服務

- 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 Tall

Le Président du Salon: Jean-Luc Vincent

co-developed with

ADVANTECH

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 celluar) 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)

Prepared by

Shenghao Yang, Xuan Huang

The Chinese University of Hong Kong, Shenzhen

Raymond W. Yeung

The Chinese University of Hong Kong

John K. Zao

National Chiao Tung University

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