Security capabilities for Light Communications

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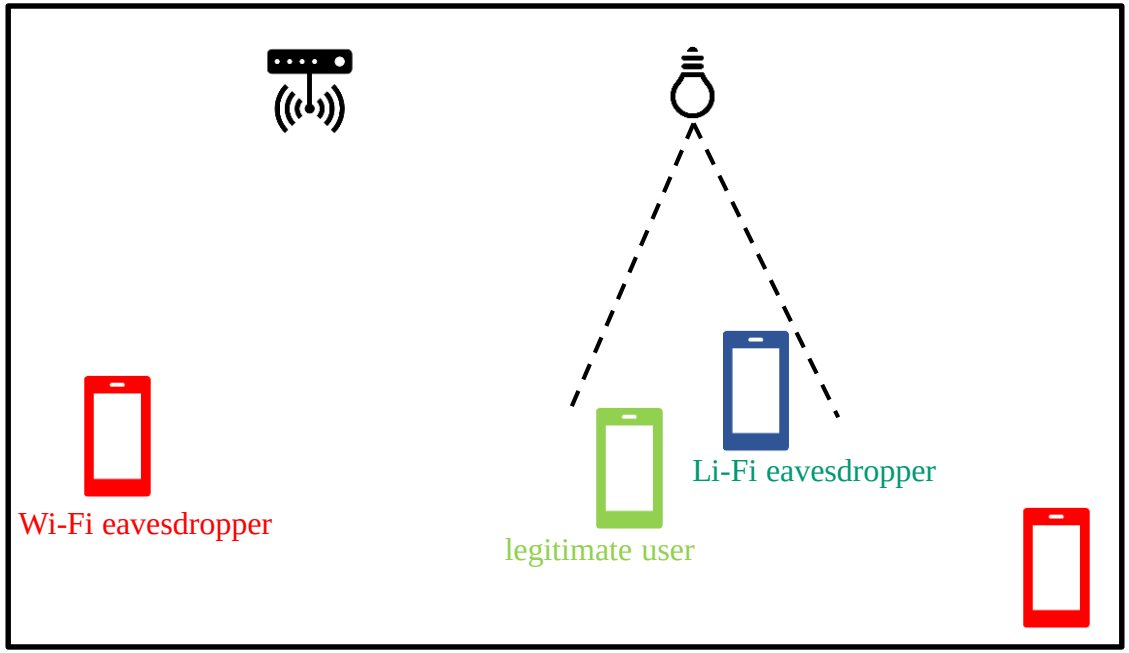
Abstract

This presentation discussed the security benefits of LC.

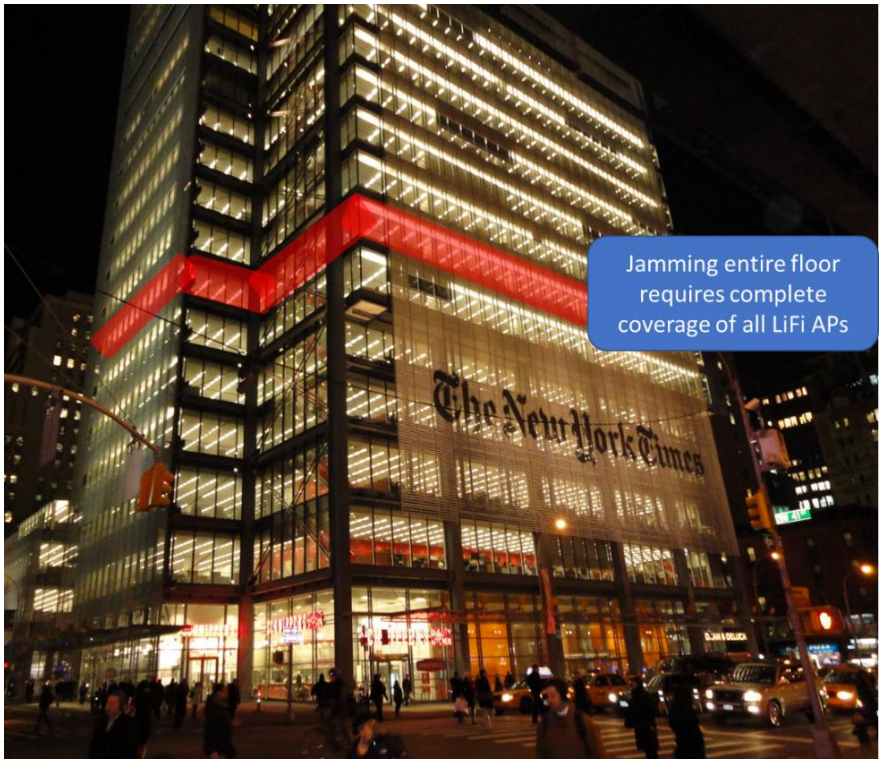
Where can eavesdroppers be?

- Wi-Fi: the location of the eavesdropper can be arbitrary
- LC: eavesdroppers have to be within the coverage are of the AP (more difficult!)



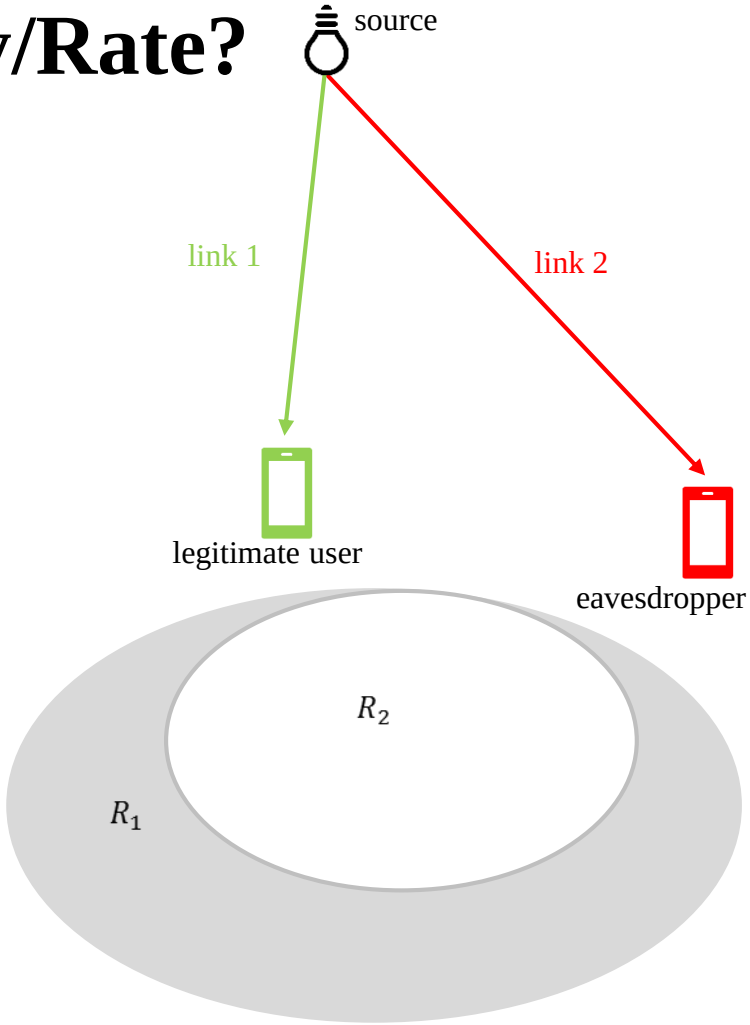
Jamming an entire LC Network?

- Jamming a LC AP typically requires the eavesdropper to use a directional beam.
- Due to the dense deployment of APs in a LC network, users are likely to roam between different AP frequently.
- It is very difficult for an eavesdropper to point to the ‘right’ AP.



What is the Secrecy Capacity/Rate?

- From an information-theoretic point of view, the secrecy capacity is $\max(0, R_1 - R_2)$.
- Secrecy rate (strictly positive and smaller than $R_1 - R_2$) is the achievable information rate that can be securely transmitted to the legitimate user.

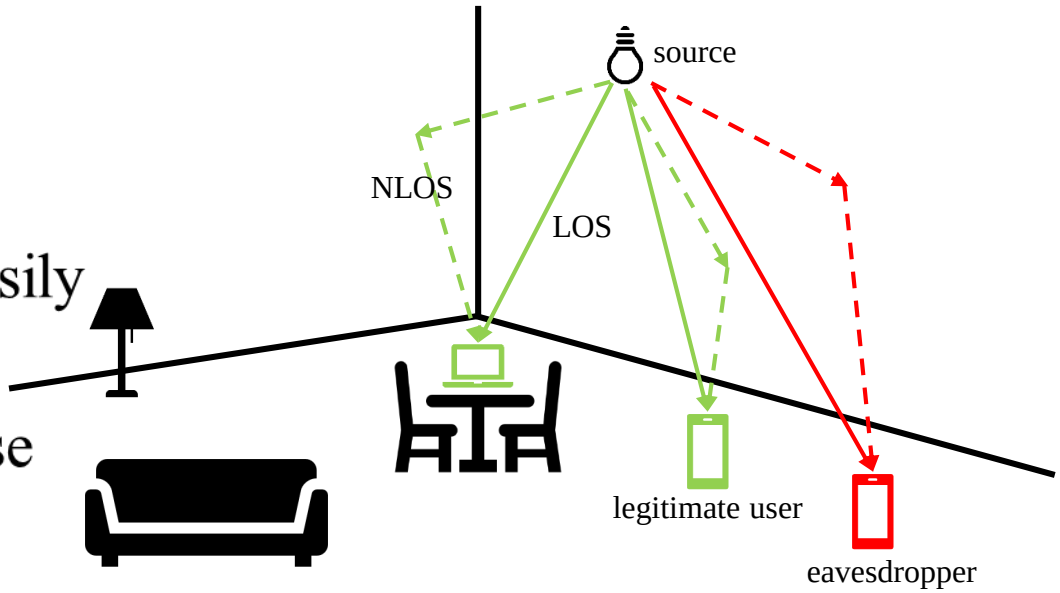


S. Leung-Yan-Cheong and M. Hellman, "The Gaussian Wire-Tap Channel," *in IEEE Trans. Inf. Theory*, vol. 24, no. 4, pp. 451-456, July 1978.

R_1: capacity of link 1 (legitimate)
R_2: capacity of link 2 (eavesdropping)

LC PHY-Security: Advantages of light

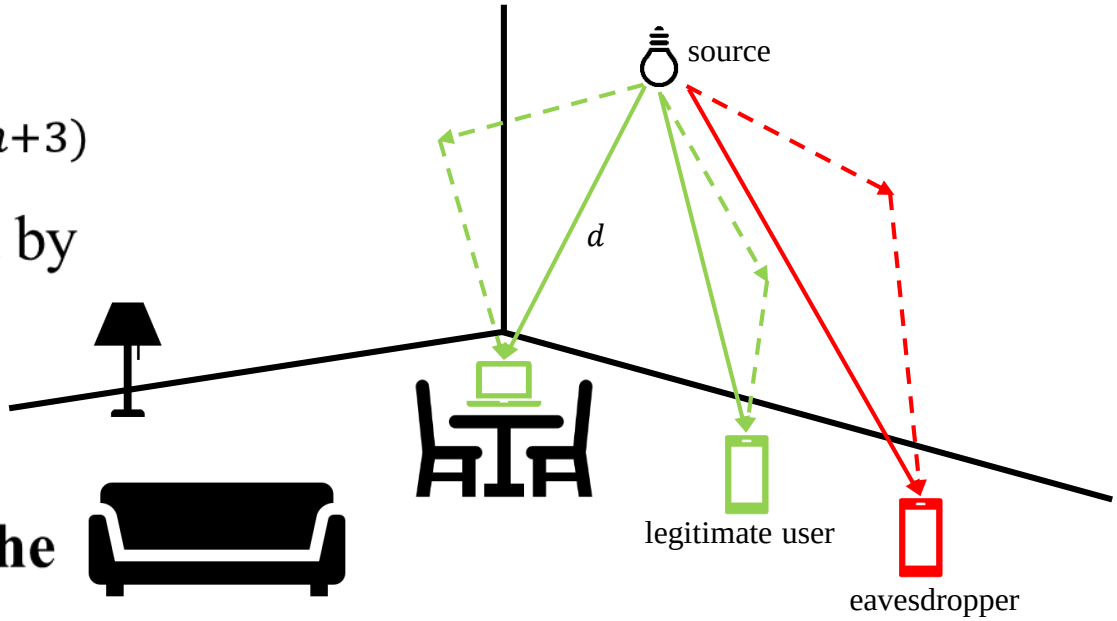
- No eavesdropping from outside the room
- Friis law: pathloss ∝ frequency^2, hence less secrecy loss
- LOS-eavesdroppers are easily identified
- NLOS-eavesdroppers cause little secrecy loss
- LEDs with built-in motion detectors can help improve network security



LC PHY-Security: Advantages of light

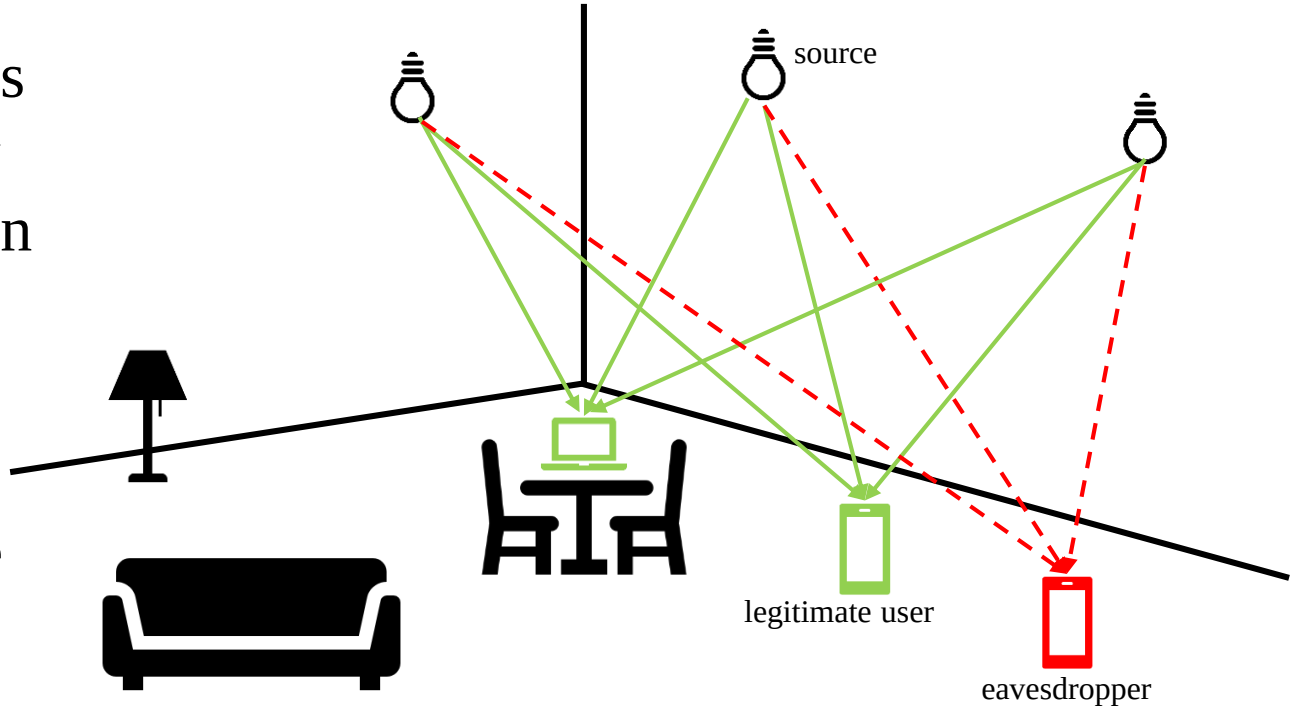
- LOS channel gain $h \propto d^{-(m+3)}$, where m is the Lambertian order
- (Electrical) SINR $\propto d^{-2(m+3)}$
- $d \times 2$ --> SINR is reduced by 24dB! (assuming $m = 1$)

- **This means if the eavesdropper has twice the link distance than the legitimate user, at least 4 bit/s/Hz secrecy rate can be achieved.**



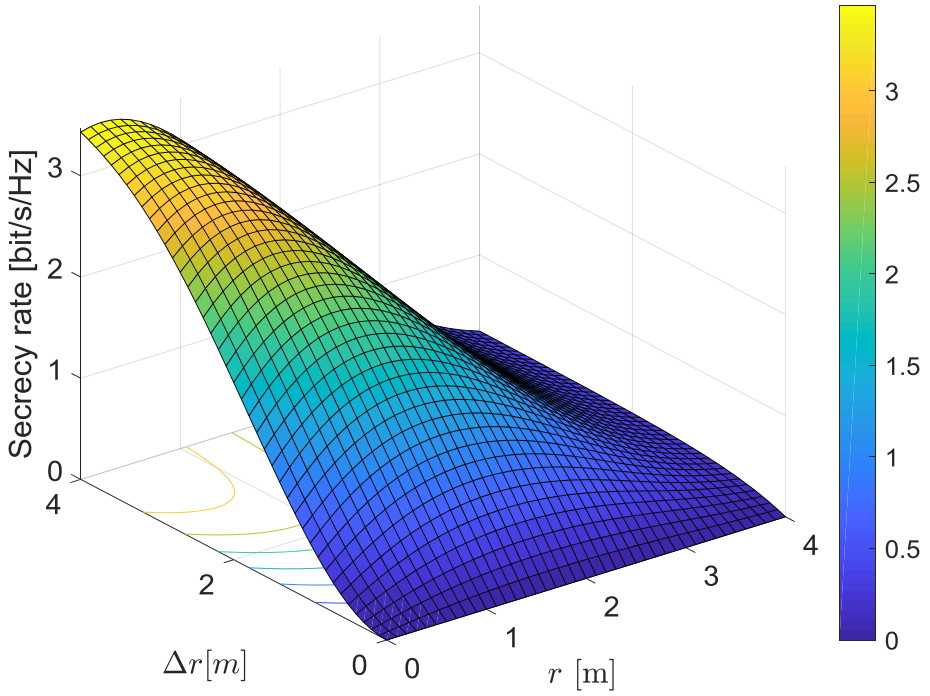
LC PHY-Security: Multiple lights can provide cooperation and improve security

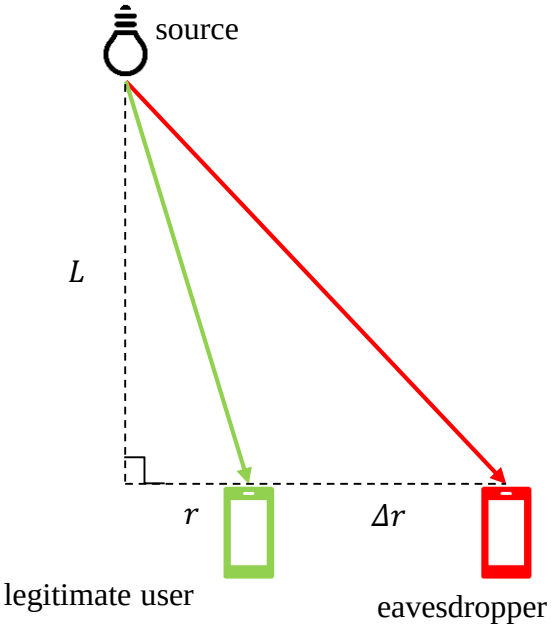
- Existing power lines offer the possibility for LED cooperation (e.g., MISO, MIMO)
- Secrecy performance can be further enhanced through precoding techniques.



A. Mostafa and L. Lampe, "Physical-layer security for MISO visible light communication channels," *IEEE J. Sel. Areas Commun.*, vol. 33, no. 9, pp. 1806-1818, Sept. 2015.

LC PHY-Security

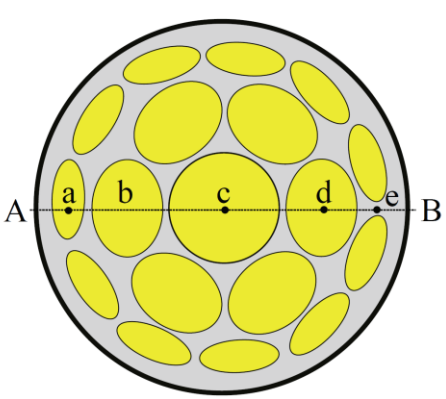


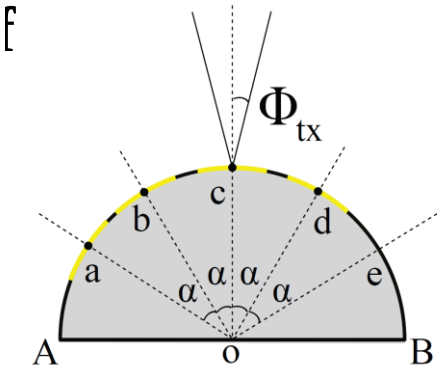


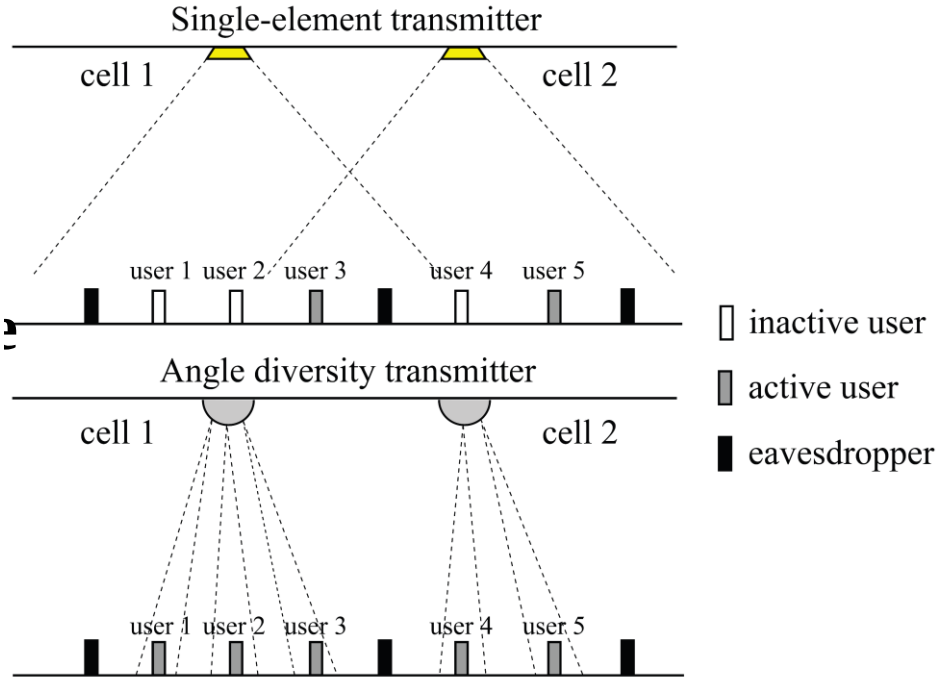
Simulation parameters:
transmit power 1 W; Lambertian order 1;
L = 2.15 m; PD area 1 cm^2;
PD responsivity 0.4 A/W.

Angle Diversity Transmitter

- **Optical beamforming**
- **Narrower beam -> more secure, also higher rate**







Z. Chen and H. Haas, "Physical-layer security for optical attocell networks," *in Proc. IEEE ICC*, Paris, 2017, pp. 1-6.