Master's Research Plan Seminar

Resource Allocation for Optical IRS-Assisted Multi-UAVs Networks

Student: DANG Dinh Khanh – m5282002

Supervisor: Prof. Anh T. PHAM

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Outline of Presentation

In recent years, the success of various projects involving HAPs (e.g., SoftBank's Sunglider in Japan) has opened a new chapter for Aerospace integrated network architecture to support a wide coverage.

- **High-altitude platforms (HAPs)**
    - Airships, aircraft.
    - Altitude: 17-25 km
    - Coverage with diameter 200 km
    - Provide connection to remote/rural/emergency areas

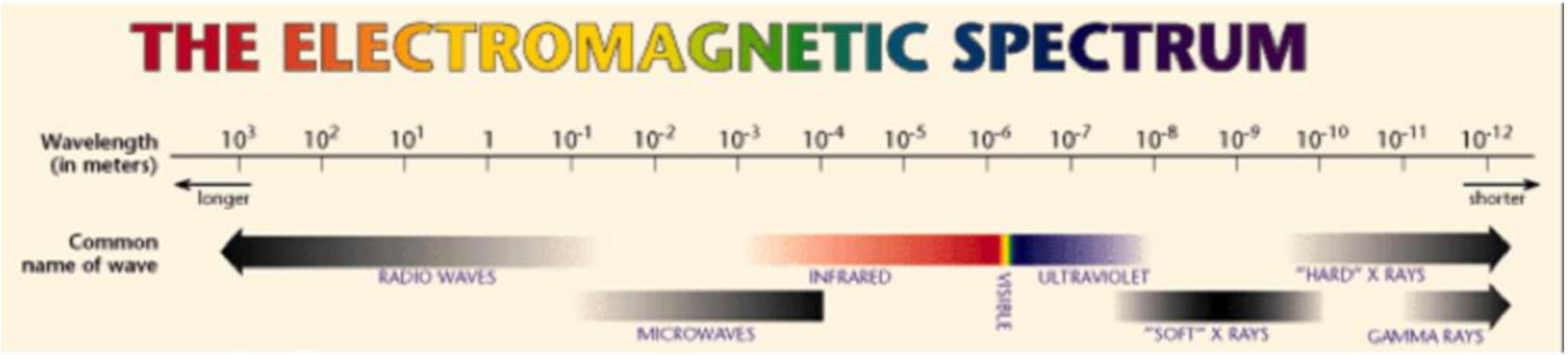
Internet from space by **high altitude platform (HAP)**

- Using RF communication: hundreds Mbps and up to a few Gbps

→ *Need **higher data rates** to support billions of users for the future 6G network.*

❖ Free Space Optical (FSO) communications

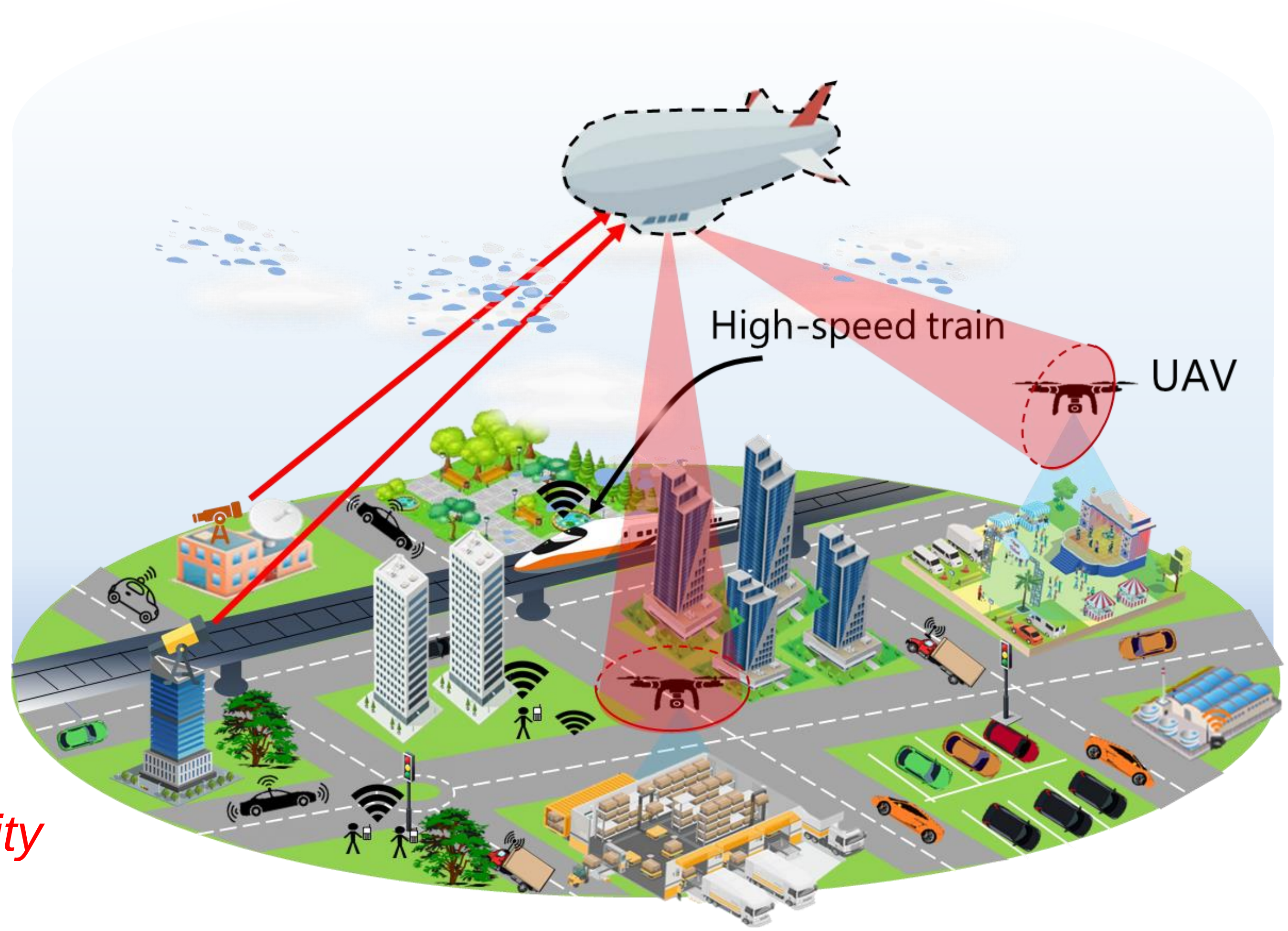
- Using infrared frequency bands *(200-400 THz)* to transmit data in free space.
- High-speed connection (Gbps and even Tbps)
- Free-license bandwidth



➡ The FSO based HAP can support *ultra-high speed data rate* and *wide coverage*.

- **FSO-based HAP network applications:**
  - Internet of Vehicles (IoV)
  - Internet of Medical Things (IoMT)
  - Internet of Senses (IoS)
  - Internet of Remote Things (IoRT)
  - Vehicle to Everything (V2X)
  - Smart Grid IoT,…

- However, using HAP as a relay can lead to *power consumption* and *hardware complexity*



The FSO-based HAP-Assisted IoV network

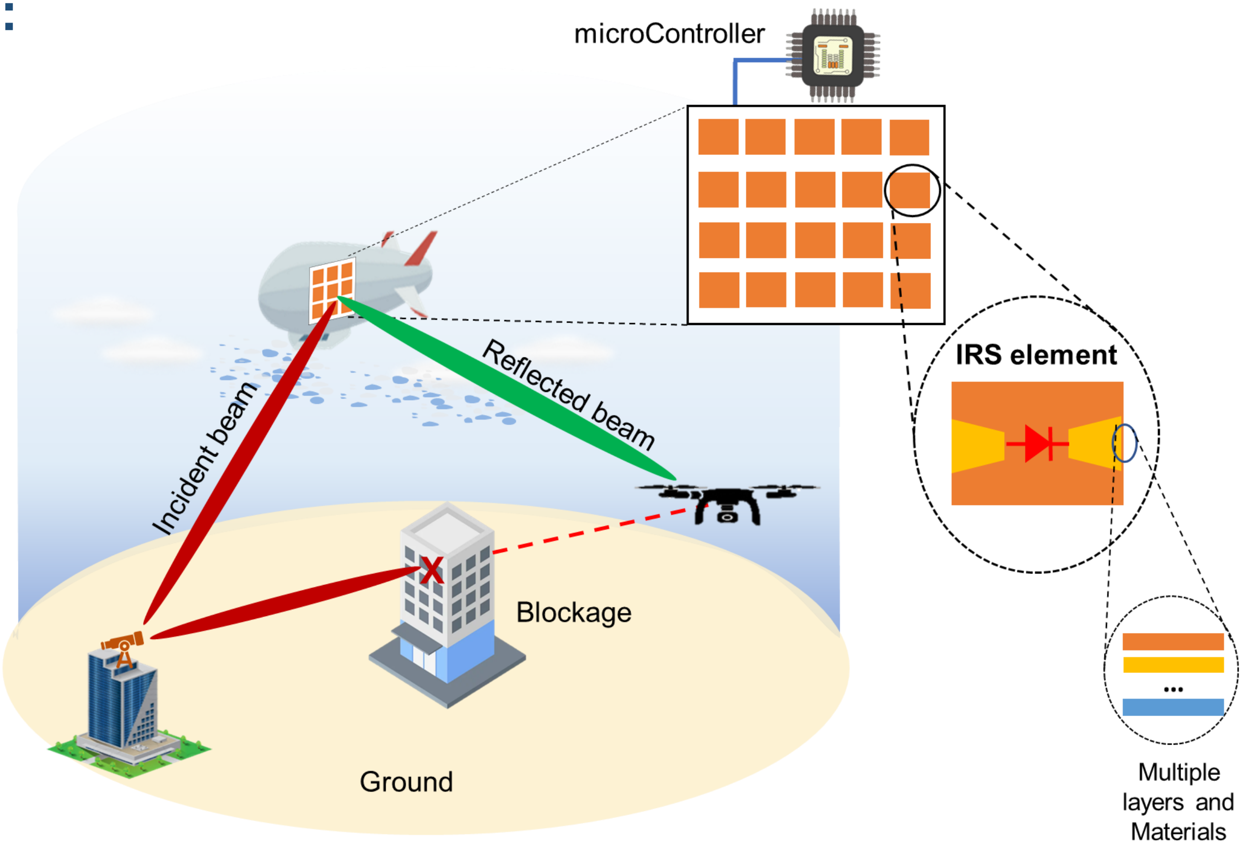
Recently, many works focus on optical intelligent reflecting surface (OIRS) as an alternative solution of conventional relay networks.

❖ Optical Intelligent Reflecting Surface (OIRS):

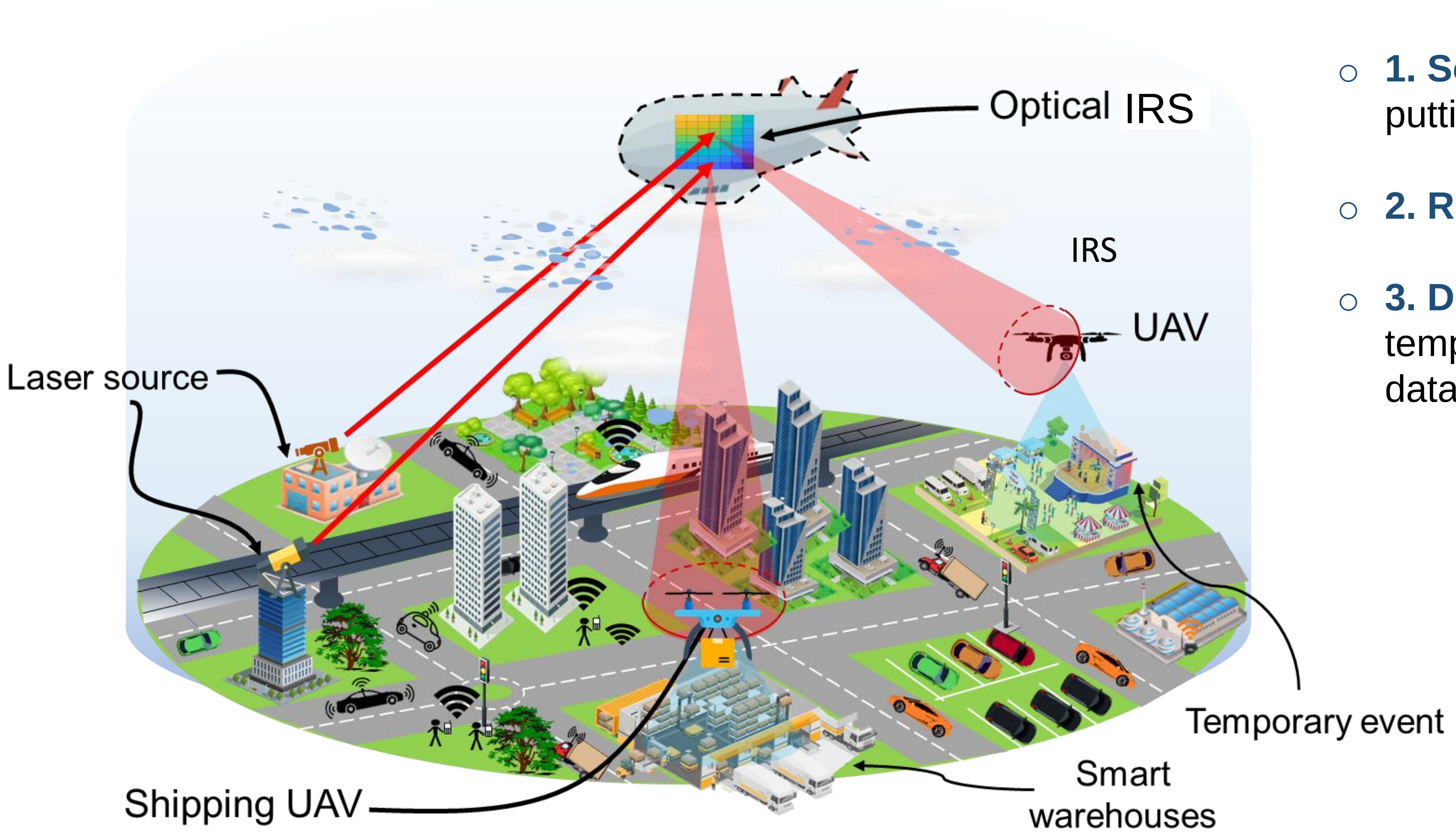
- An artificial surface, made of mirrors and nearly passive elements.
- IRS *controls and manipulates the impinging waves* into the expected directions.

❖ Advantages

- *Low power consumption.*
- *Low complexity and cost-effectiveness*
- *Extend coverage and avoid blockage*



Therefore, IRS can be used for the FSO-based HAP network to support IoV applications.



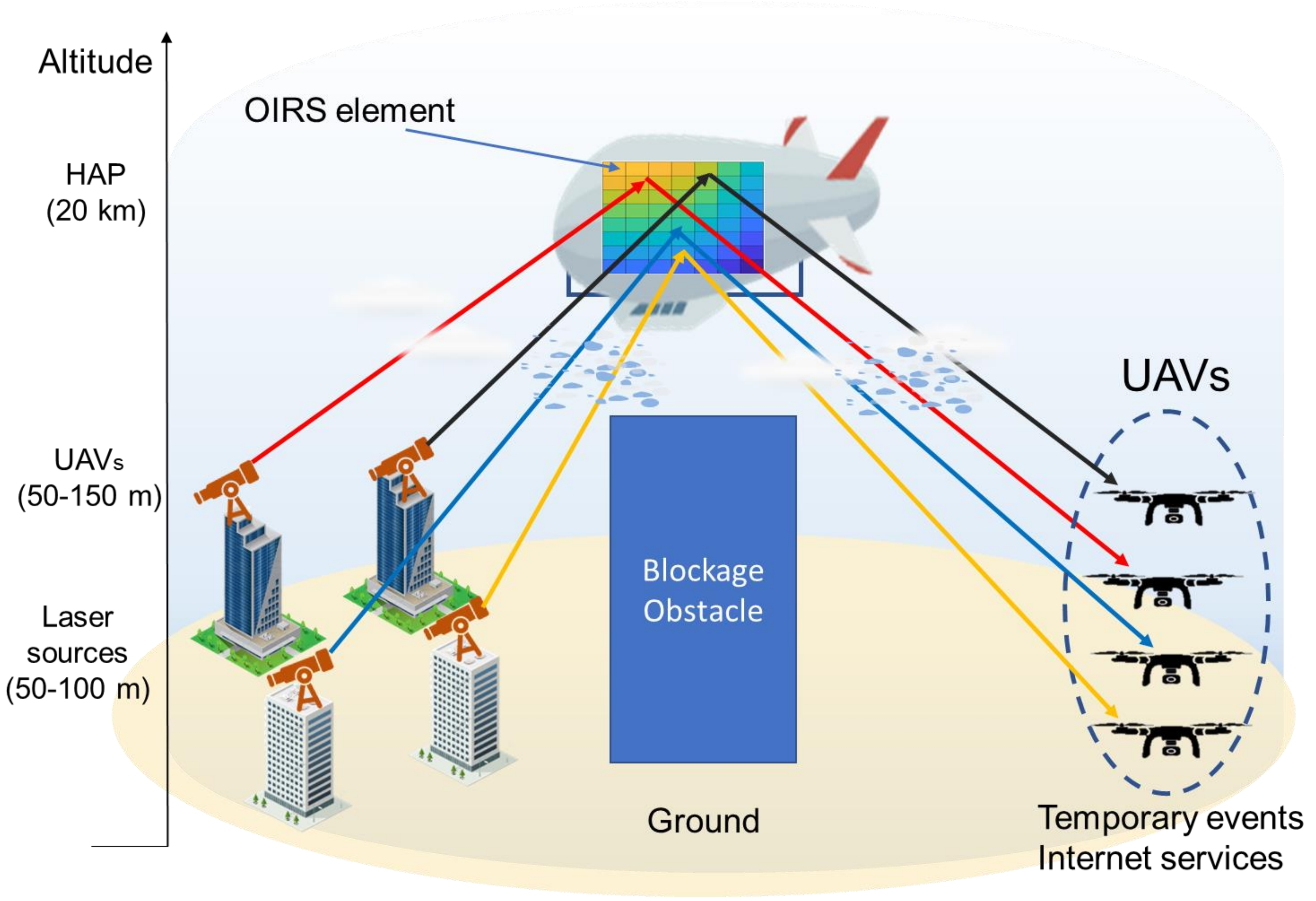
FSO-based HAP-Assisted Multi-UAVs with IRS

❖ System description:

- **1. Sources:** multiple laser sources putting in the top of buildings
- **2. Relay:** one OIRS mounted HAP
- **3. Destinations:** multiple UAVs for temporary event, shipping, rescue, data collection service.

❖ Advantages

- Ubiquitous connections
- Wide coverage
- Ultra-high data rate
- Flexible deployment
- Wide range of applications



Limited OIRS Resources

The limited OIRS size mounted in HAP restricts the number of OIRS elements, creating critical issues in **sharing these elements** among multiple UAVs.

Resource Allocation
for OIRS supporting multiple UAVs

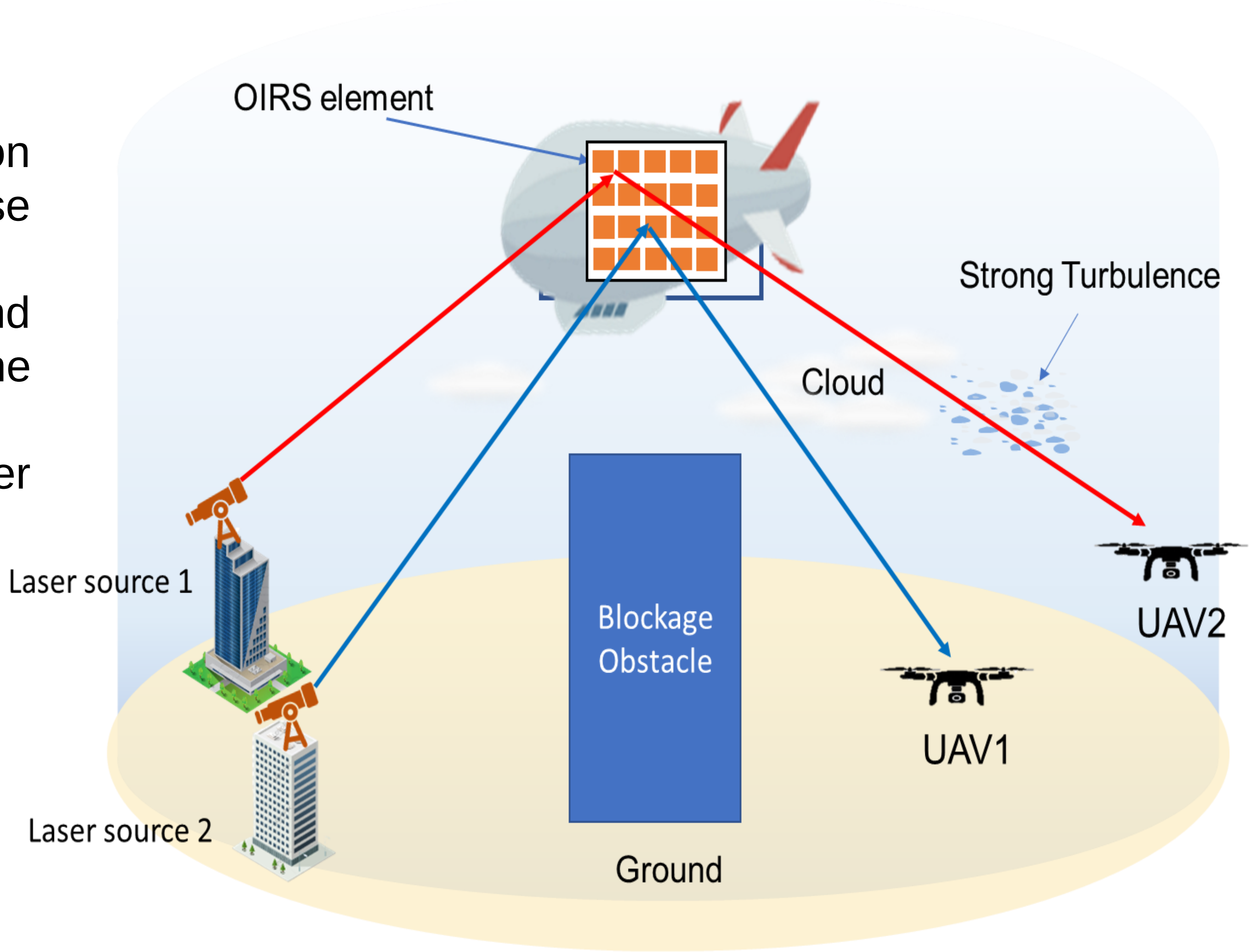
Given:
- Different time-varying channels
- Maintain targeted Quality of Service (QoS) among all UAVs

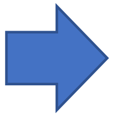
❖ Time-varying Channel Condition:

- **Atmospheric turbulence:** random phenomenon temperature and pressure of atmospheric cause the scintillation effect.
- **Atmospheric attenuation:** the gas molecules and aerosol particles in atmospheric cause the absorbing and scattering phenomenon.
- **Pointing error:** misalignment between the center of FSO beam footprint and UAV detector.

For example:

- UAV1 is in *good channel condition*, need fewer OIRS elements.
- UAV2 is in *very bad channel condition*, need more OIRS elements.

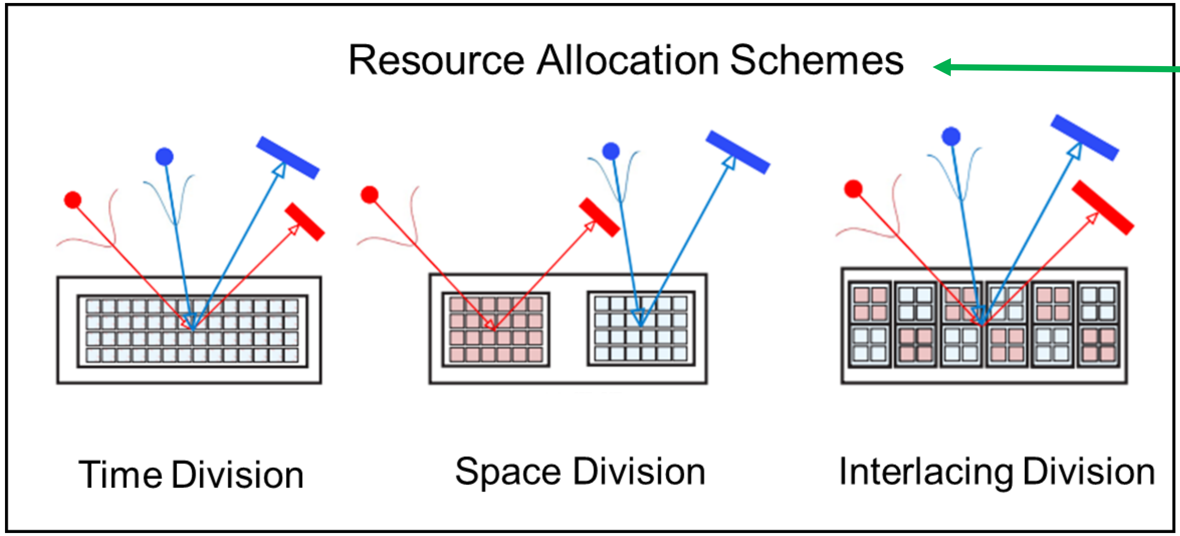


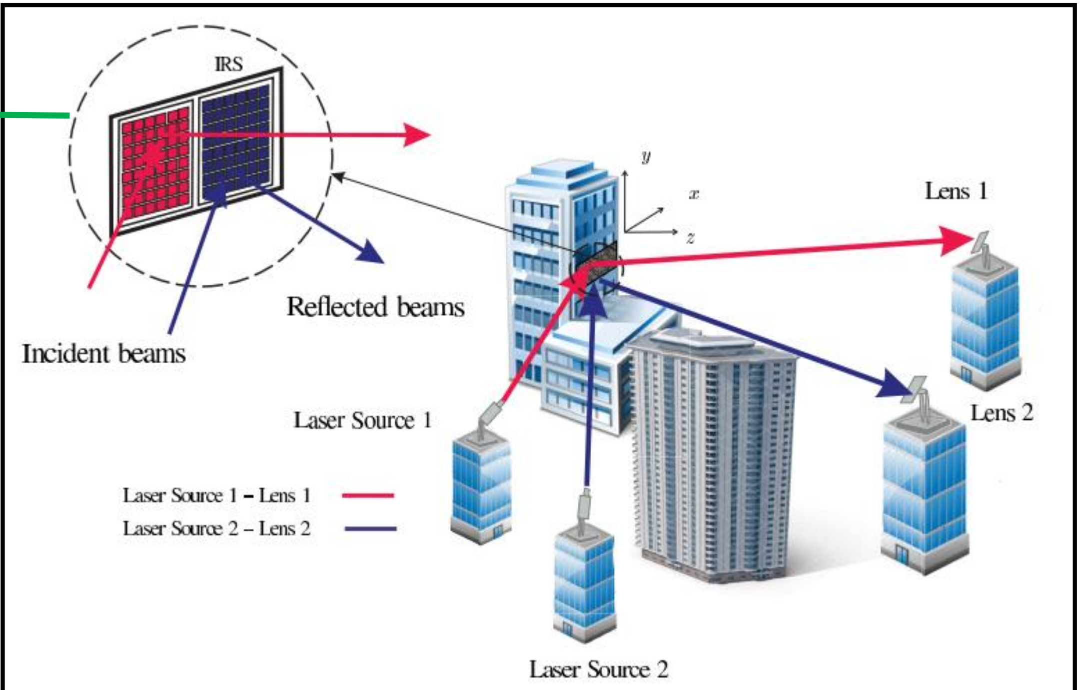


It's important to consider the *dynamic channel conditions* among UAVs to *allocate OIRS elements* for *maintaining a targeted QoS*

❑ Terrestrial Networks

Many studies *have well investigated* the OIRS to enhance line-of-sight communication, physical-layer security, and *resource allocation* for *both single user and multiple users* [1]-[3].





OIRS-assisted Terrestrial Networks [1]

➡ However, these schemes *allocate OIRS equally* to multiple users and is *not straight-forward* to apply in space with *dynamic channel conditions.*

❑ Space Networks

In space networks, many studies have focused on using IRS to avoid bad weather conditions or blockage connections in the context of a single user [4]-[6].

Reference	Summary
[4]-2022	Analyze the performance of a reconfigurable intelligent surface (RIS)-assisted unmanned aerial vehicle (UAV) wireless system that is affected by mixture-gamma small-scale fading, stochastic disorientation and misalignment, as well as transceivers hardware imperfections. *=> Do not consider resource allocation*
[5]-2023	This paper examines hybrid FSO-RF relay systems in satellite-terrestrial networks, considering weather effects and propose design three relay schemes for varying weather using HAPS and RIS-assisted UAVs. *=> Can't support in term of multiple users simultaneously*
[6]-2024	Introduce multi-hop fully FSO-backhaul link, connecting ground stations through RIS-embedded UAVs. *=> Do not consider the multiple users and time-varying channel*

➡ Resource allocation for ORIS supporting *multiple users* considering different *time-varying channel conditions and QoS* of all UAVs is not available.

❖ Research Goal

- I want to propose a ***resource allocation mechanism based on Space and Interlacing Division*** considering ***(1) the different channel conditions***, ***(2) fixed OIRS elements***, and the ***(3) Quality of Services (QoS)*** *(e.g Outage Probability/Bit error rate) among UAVs.*

➡ ***Calculate the required number of OIRS elements*** $\left(n_i\right)$ for each UAVs.

➡ ***Determine the coordinates of each OIRS element*** $\left(x_i, y_i\right)$ in OIRS panel.

$$Throughput_i, \tau_i = f\left(n_i, x_j, y_k\right)$$

$$\max_{(n_i, x_j, y_k)} \left(Total\_Throughput\right) = \sum_{i=1}^{N} \tau(i),$$

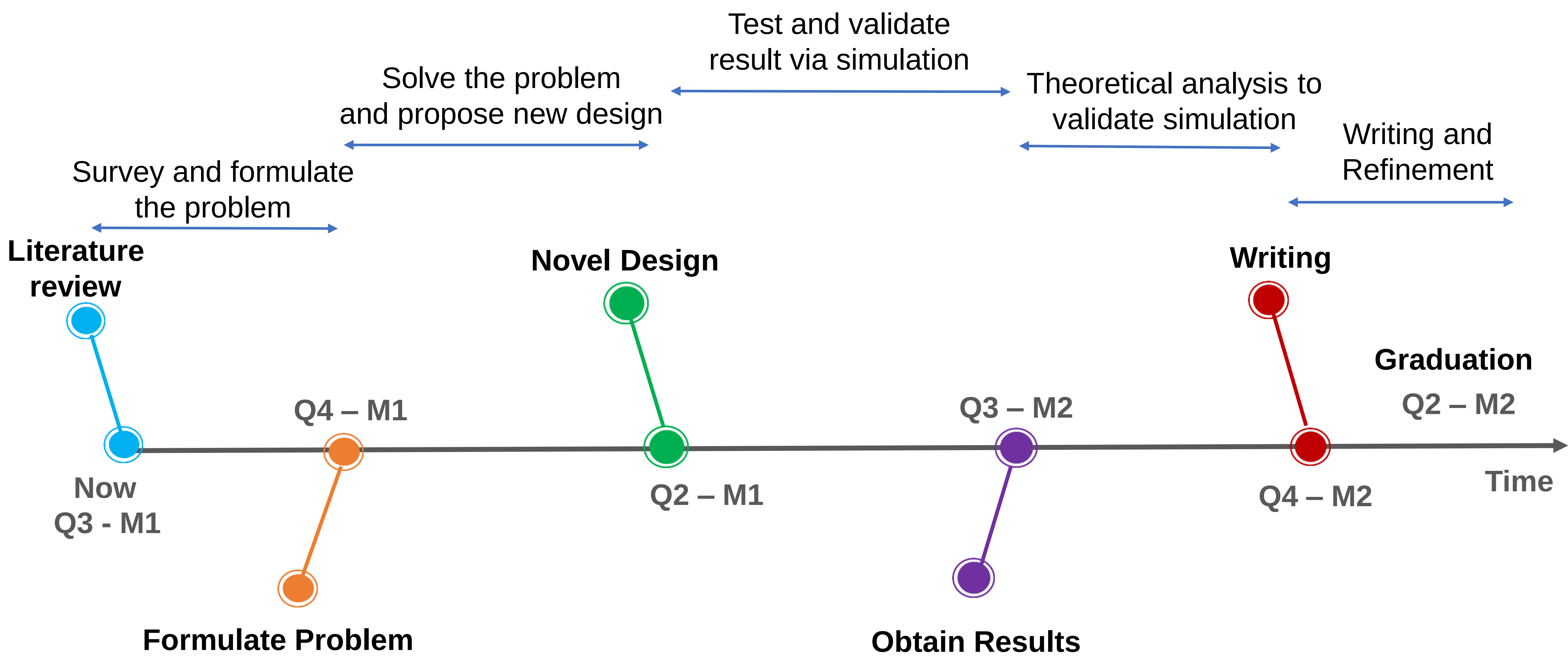
$$\text{s.t } QoS_{\text{targeted}}, \text{fixed OIRS size} = M_X \times M_Y$$

where $i \in \{1, 2, ..., N\}$, where N is number of UAVs,

$j \in \{1, 2, ..., M_X\}$, where M_X is number of OIRS in X coordinate,

$k \in \{1, 2, ..., M_Y\}$, where M_Y is number of OIRS in Y coordinate.

4. Research Goal and Plan Timeline



THANK YOU FOR LISTENING!

Reference

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