Zyxel-NYCU Project: AI-Empowered Wi-Fi Self-Optimization and User Association Scheme

Monthly Progress Report: July 2021

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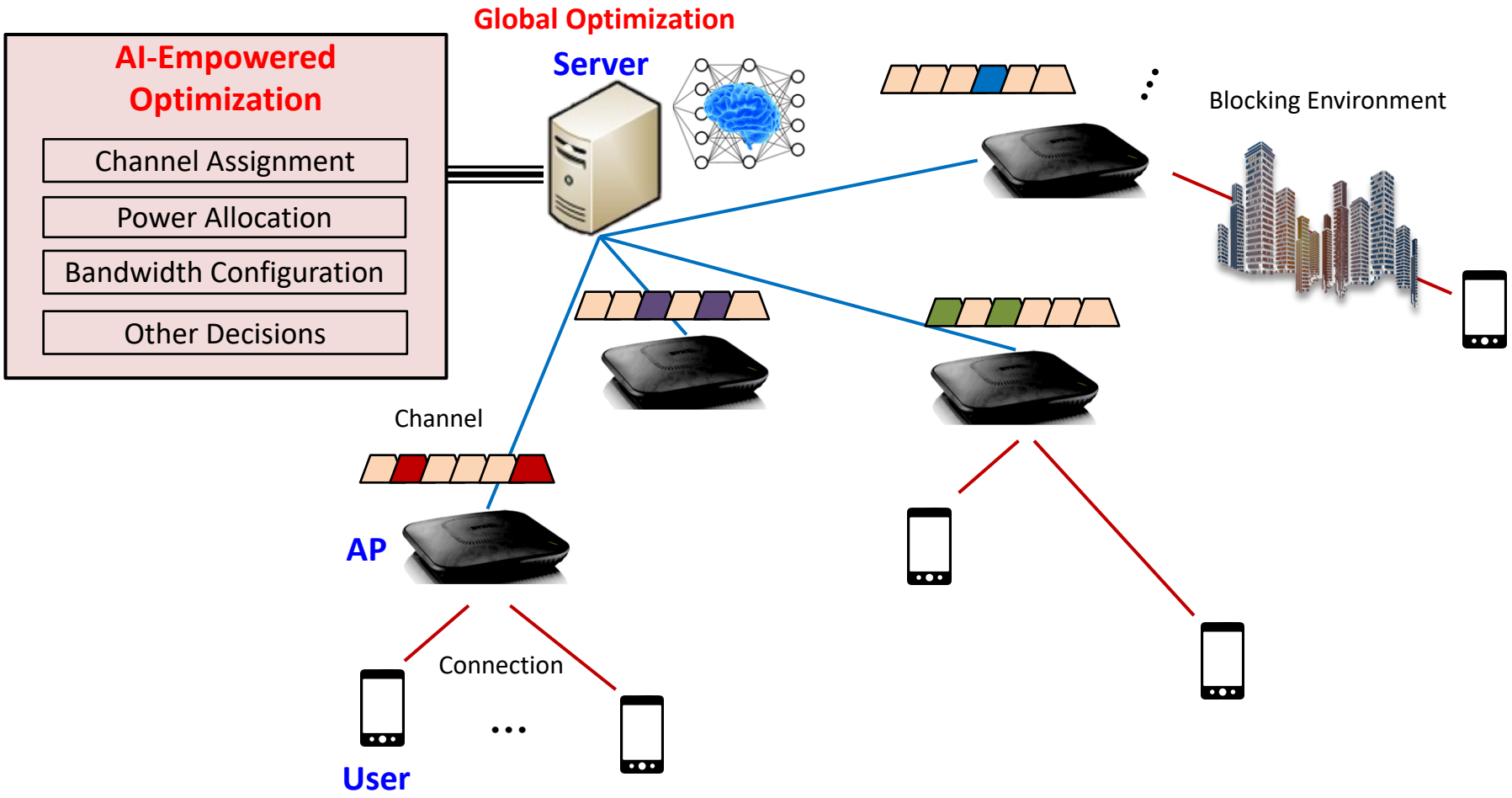
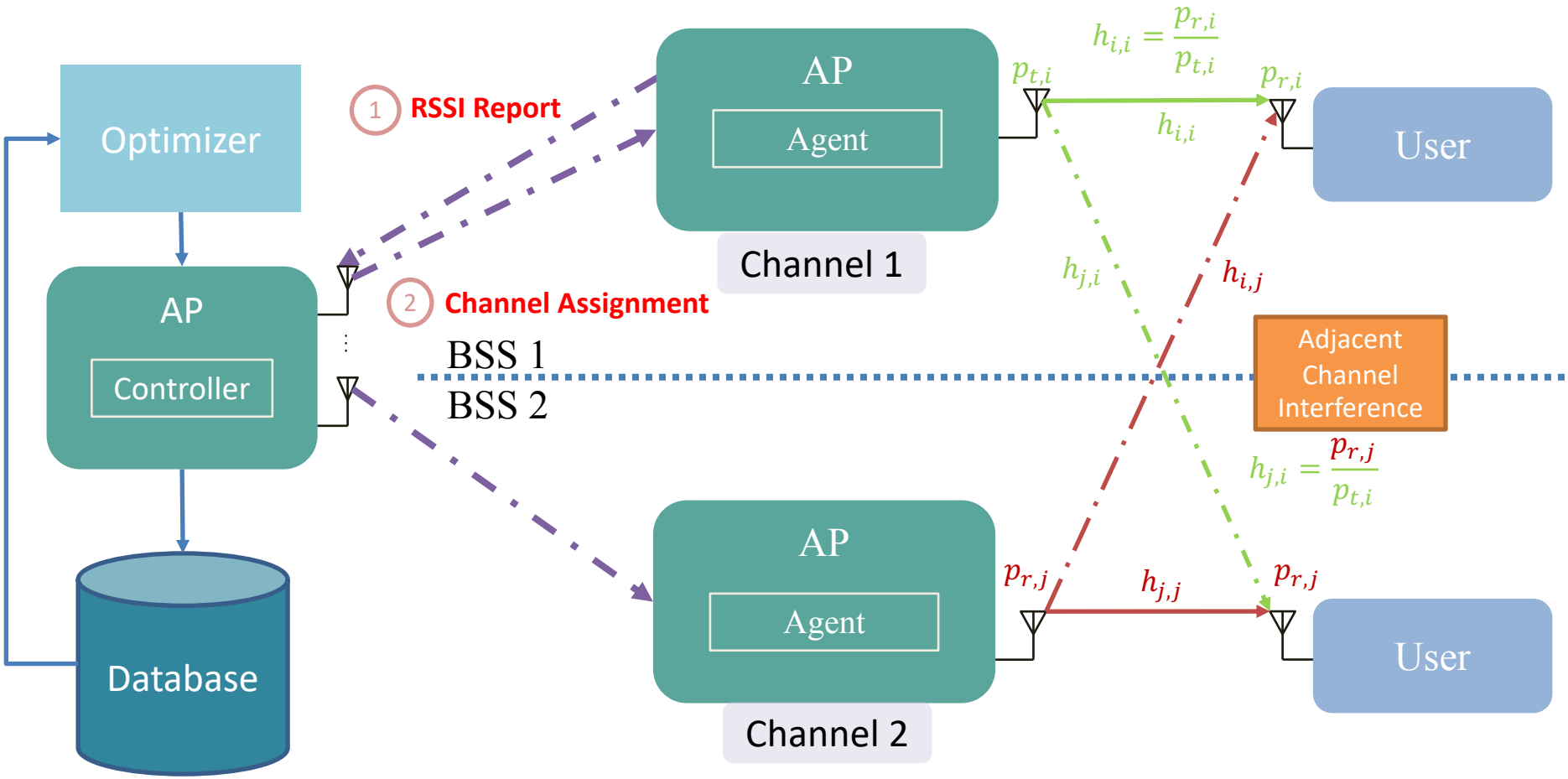
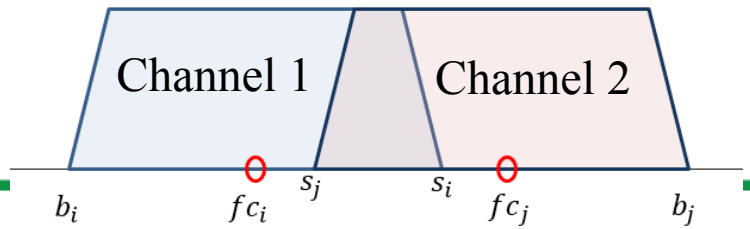
Project Scenario



System Diagram





$$\gamma_{c_i c_j} = \frac{\max(0,\ s_i - s_j)}{|s_i - b_i|}$$

Interference level $\boldsymbol{\Gamma} = (\gamma_{c_i c_j}) \in \mathrm{R}^{\mathrm{C}\times\mathrm{C}}$

System Model

- Channel selection matrix $\boldsymbol{A} = (\alpha_{i,c}) \in \mathbb{R}^{\mathrm{N}\times\mathrm{C}}$:

$$\begin{bmatrix} 1 & \dots & 0 \\ 0 & \dots & 1 \\ 1 & \underbrace{\dots}_{\text{All Zeros}} & 0 \end{bmatrix}$$

- Selected channel interference level $\mathbf{E} = (\mathrm{e_{ij}}) = \boldsymbol{A\Gamma A}^T \in \mathbb{R}^{\mathrm{N}\times\mathrm{N}}$
  - $\boldsymbol{A}$: Use the row vector to select a row of channel interference level , indicating latent interference
  - $\boldsymbol{A}^T$: Filter out the true interference
  - Physical meaning : e_{ij} is the interference level between AP i and AP j

- Let $\boldsymbol{B} = \boldsymbol{A}^T$
  - $\beta_{ci} = \alpha_{ic}$
- Power allocation matrix **P** = $(p_{ic}) \in \mathbb{R}^{\mathrm{N}\times\mathrm{C}}$
- Bandwidth Vector : $\boldsymbol{b} = (b_i) \in \mathbb{R}^{\mathrm{N}\times 1}$

Notation Description

	Description	Acquirement	Role
N	# APs in this architecture	-	Media
C	Number of operating channels defined in spec.	1. Wireless LAN MAC and PHY specification 2. C = 41 in Taiwan	Media
N_0	AWGN	-174 dBm/Hz	Media
$\gamma_{c_i c_j}$	Channel interference level between channel c_i and c_j	Wireless LAN MAC and PHY specification	Media
T_T	Trigger frame phase	100 μs	Media
T_D	Payload phase	100 μs	Media
T_M	ACK phase	40 μs	Media
e_m	Error probability of specific *m* MCS level	Wireless LAN MAC and PHY specification	Media
l	Packets length	Wireless LAN MAC and PHY specification	Media
e_{th}	Allowable packet error rate	Manual settings	**Input**
h_{ij}	Channel gain between AP j and user of AP i	RSSI and path loss transformation	**Input**
b_i	Channel bandwidth deployed on AP i	[20, 40, 80, 160] MHz	**Output**
p_{ic}	Power of AP *i* operating on channel *c*	Transmit power control [5, 10, 15, 20] dBm	**Output**
α_{ic} 、β_{ci}	Indicator variable : Whether AP i is operating on channel c	Self defined channel selection matrix	**Output**

Problem Formulation

- Problem formulation:

$$\max_{\boldsymbol{P},\boldsymbol{A},\boldsymbol{b}} \quad \Gamma = \left(\frac{T_D}{T_T + T_D + T_M}\right) \sum_{\mathrm{i}=1}^{\mathrm{N}} \sum_{\mathrm{c}=1}^{\mathrm{C}} \mathrm{b}_i \log_2 \left(1 + \frac{\mathrm{h_{ii}} \alpha_{\mathrm{ic}} p_{\mathrm{ic}}}{\sum_{\mathrm{j}=1,\mathrm{j}\neq\mathrm{i}}^{\mathrm{BS}} \alpha_{\mathrm{jc}} \gamma_{c_i c_j} \beta_{cj} \mathrm{h}_{ij} \alpha_{\mathrm{jc}} p_{\mathrm{jc}} + N_0}\right)$$

Channel Gain; Transmit Power; Operating channel indicator; Interference level; Noise

s.t.

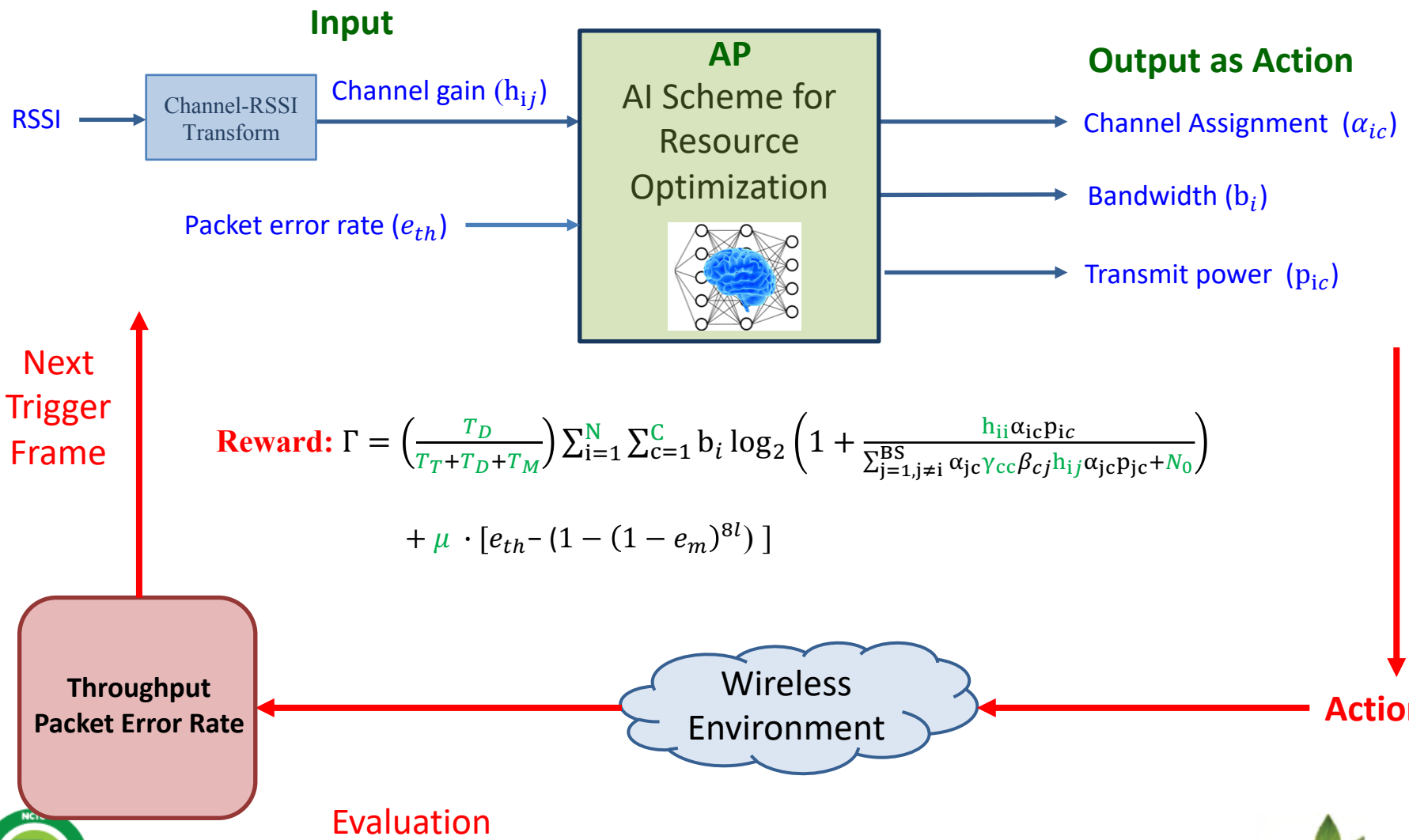
$$PER = 1 - (1 - e_m)^{8l} < e_{th}$$

Packet length

P_m = f(Γ)

- **Action** :
  - α_{ic}: channel selection index
  - p_{ic} : transmit power control, i.e., [5, 10, 15, 20] dbm
  - b_i : bandwidth deployed on specific AP i, i.e., [20, 40, 80, 160]

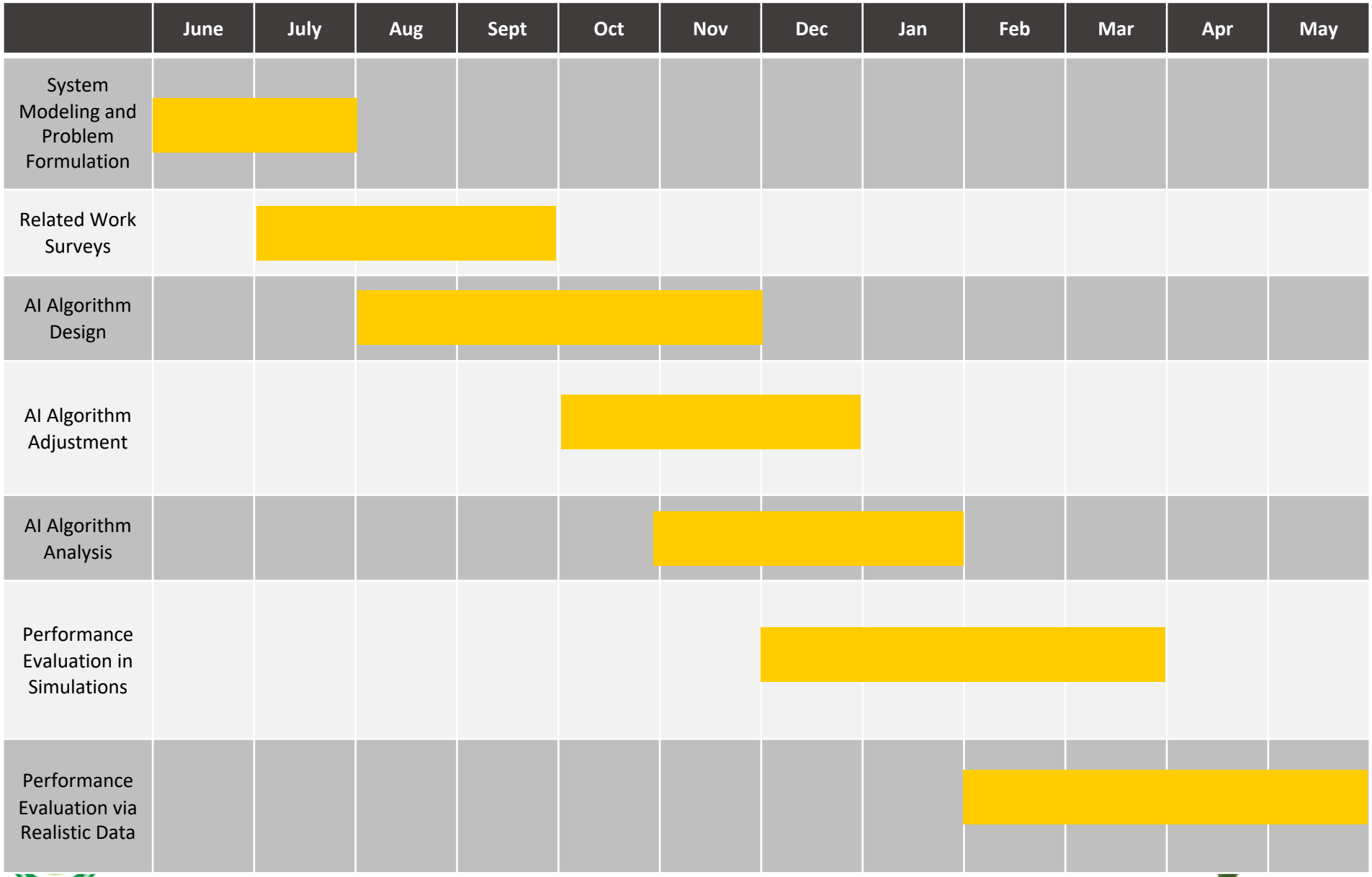
AI Optimizer Design



Discussions

- Which are the available channels in your 802.11ax system?
- What are the available transmit power to be utilized?
  - Continuous power or discrete power level
- Is it feasible to obtain RSSI among APs?
- What is the reasonable number of users considered in 802.11ax network?
- **Beacon interval** is not feasible to be considered in our current problem formulation
  - We optimize over an averaged channel environment within a frame period
  - The selection of beacon interval will be influenced by how often we update our algorithm
    - We may consider to add another Beacon Interval Optimizer afterwards

Gantt Chart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System Modeling and Problem Formulation
Related Work Surveys
AI Algorithm Design
AI Algorithm Adjustment
AI Algorithm Analysis
Performance Evaluation in Simulations
Performance Evaluation via Realistic Data

Thank You

Q & A