Dynamic resource control method based on real world representation with potential field

Koudai Kanda
Graduate School of Information Science and Technology, Osaka University, Japan

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Background of research

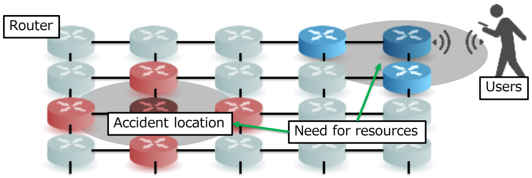
- **The recent mobile devices is equipped with sensors**
  - These sensors make it possible to capture our real-world information
- **Application using mobile devices increases**

  e.g.) The real-world sensing
    - It analyzes the surrounding real world information via sensors
    - Based on the results, it provides services such as navigation
  - Sensor information is aggregated in data center
  - Based on analysis and extraction, application provides services[1]
- **Delays occur due to the aggregation of information in data centers**

[1] : D. Taniuchi and T. Maekawa, "Automatic update of indoor location finngerprints with pedestrian dead reckoning," ACM Transactions on Embedded Computing Systems (TECS), vol. 14, no. 2, p. 27, 2015.

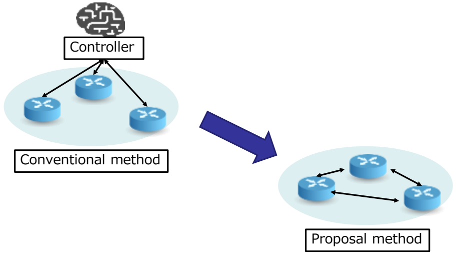
Need for dynamic resource control

- **e.g.)Traffic accident**
  - Sensor information occurs immediately at the accident location
  - Access to information occurs from users
  - Need resources for deal with information and access



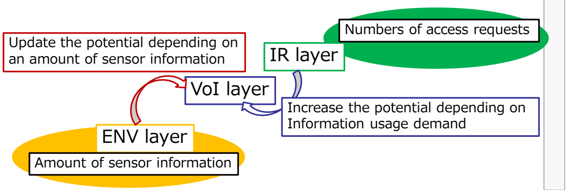
Purpose of research

- **Propose a dynamic resource control method**
  - Control with short interval for self-organizing
  - Consider the spatio-temporal dynamics of users in the real world



Approach of method

- **Introduce potential field to reflect the following items**
  - Amount of sensor information
  - Numbers of access requests
- **VoI layer**
  - Allocate resources based on the potential of this layer
  - Interact with other layers

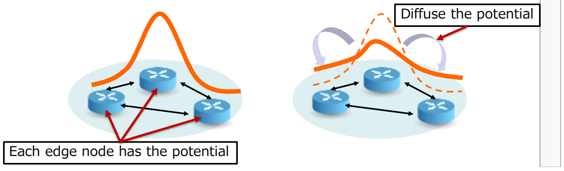


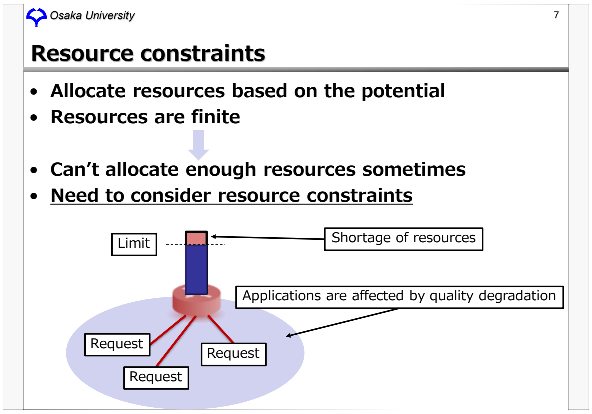
Update the potential depending on an amount of sensor information

Increase the potential depending on Information usage demand

Spatio-temporal dynamics

- **Consider the spatio-temporal dynamics in VoI layer**
  - Let the potential of node z is high
  - Spatio dynamics
    - Users access to not only z, but also edge routers close to z
  - Temporal dynamics
    - Potential is not lost immediately
- **Diffuse the potential as the spatio-temporal interaction**





Resource constraints

- **Allocate resources based on the potential**
- **Resources are finite**

- **Can't allocate enough resources sometimes**
- **<u>Need to consider resource constraints</u>**

Limit

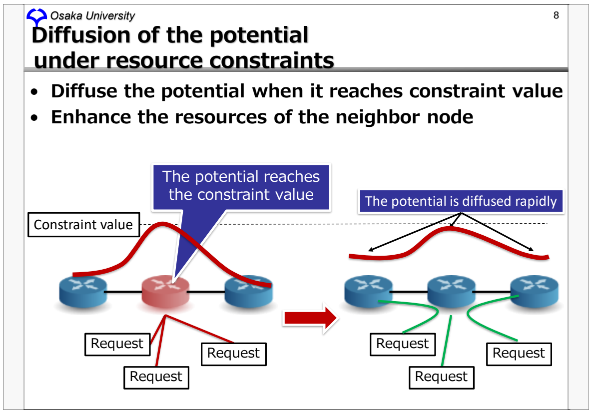
Shortage of resources

Applications are affected by quality degradation

Request

Request

Request



Diffusion of the potential under resource constraints

- **Diffuse the potential when it reaches constraint value**
- **Enhance the resources of the neighbor node**

The potential reaches the constraint value

Constraint value

The potential is diffused rapidly

Request

Request

Request

Request

Request

Request

Update potential equation in VoI layer

- $I(t, x, y)$ **is updated by the following equation**

Amount of sensor information

- $C(t+1, x, y) = (1 - D_u)p(t, x, y) + \frac{1}{|A_i|} D_u \sum_j^{A_i} C_j$
- $D_c = \begin{cases} D_t \frac{\partial C(t,x,y)}{\partial t}, & \frac{\partial C(t,x,y)}{\partial t} > 0 \\ D_t \frac{\partial C(t,x,y)}{\partial t} \tanh G \cdot I(t, x, y), & \frac{\partial C(t,x,y)}{\partial t} < 0 \end{cases}$
- $\frac{\partial I(t,x,y)}{\partial t} = \boxed{Pf + D_c} + \boxed{D_v \left\{ \frac{\partial I(t,x,y)}{\partial^2 x} + \frac{\partial I(t,x,y)}{\partial^2 y} \right\}} - n$

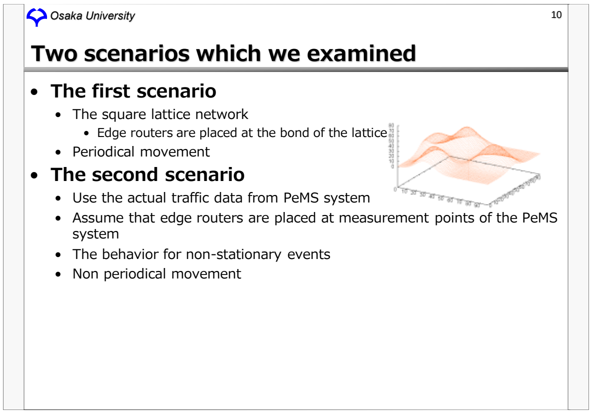
Interactions

Diffusion

- $D_v = \begin{cases} D_1\ (When\ I(t, x, y) < the\ threshold\ value) \\ D_2\ (When\ I(t, x, y) \geq the\ threshold\ value) \end{cases}$

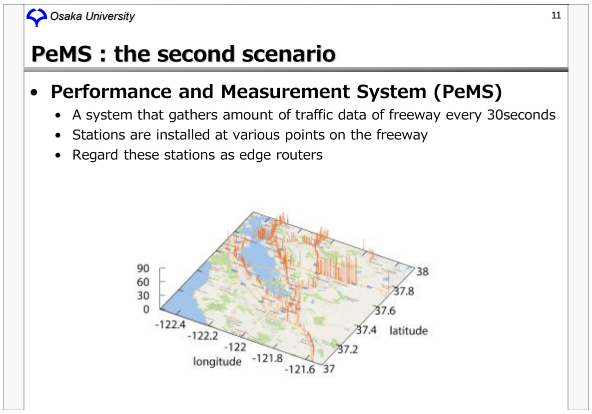
Explanation of each constant and parameter

C	Internal variable
D_u	Diffusion coefficient of C
$p(t.x.y)$	Amount of sensor information
$I(t, x, y)$	Potential
Pf	Interaction from IR layer
D_v	Diffusion coefficient of I
n	Fixed decrease value
D_t	Magnification of C
G	Reduction coefficient
A_i	A set of adjacent nodes of node i



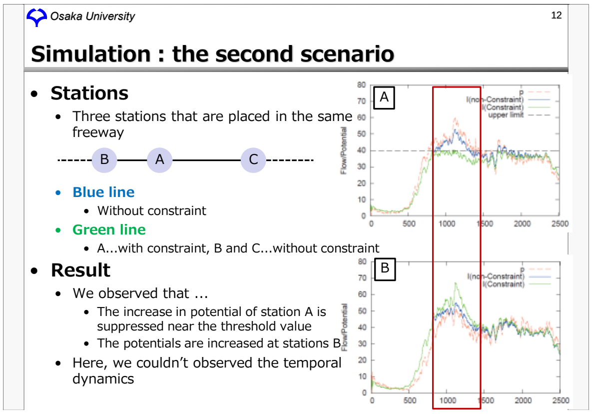
Two scenarios which we examined

- **The first scenario**
  - The square lattice network
    - Edge routers are placed at the bond of the lattice
  - Periodical movement
- **The second scenario**
  - Use the actual traffic data from PeMS system
  - Assume that edge routers are placed at measurement points of the PeMS system
  - The behavior for non-stationary events
  - Non periodical movement



PeMS : the second scenario

- **Performance and Measurement System (PeMS)**
  - A system that gathers amount of traffic data of freeway every 30seconds
  - Stations are installed at various points on the freeway
  - Regard these stations as edge routers



Simulation : the second scenario

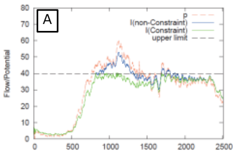
- **Stations**
  - Three stations that are placed in the same freeway

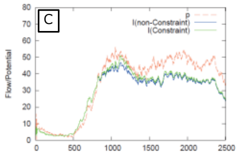
B A C

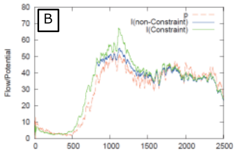
  - **Blue line**
    - Without constraint
  - **Green line**
    - A...with constraint, B and C...without constraint
- **Result**
  - We observed that …
    - The increase in potential of station A is suppressed near the threshold value
    - The potentials are increased at stations B
  - Here, we couldn't observed the temporal dynamics

Simulation : the second scenario

- **Ascending value**
  - The ascending value of station B is much lager than station C
  - The reason is that the distance from A to B and the one from A to C are differenrt







Conclusion and Future work

- **Conclusion**
  - Proposed the dynamic resource control method using the potential fields
  - Considered diffusion, interacts, and constraints
  - Observed the behavior after changing the number of users under resource constraints

- **Future work**
  - Interaction between layers
  - Evaluation of influences of each parameter on potential fields
  - Modifications of equations may necessary to handle the distance between stations