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[Poster Presentation] Computational Capability and Radio Resource Allocation for Mobile Edge Computing

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Abstract Due to the rapid advancement of the computing power of mobile devices, the interest in mobile applications and services have been rapidly growing. Since the computing power of mobile devices are not yet to be sufficient to process heavy tasks, the concept of mobile edge computing (MEC) has attracted huge attention. A MEC server which can process such heavy tasks is located at the edge of the radio access network (RAN) such as a base station (BS). Thus, mobile user (MU) can request the MEC server to process the task that it wishes to execute, and get the response within short time. If multiple MUs possess tasks that need to be processed by MEC server, MUs and MEC need to transmit and receive tasks using limited radio resources. In addition, MEC server also has to handle multiple tasks. Therefore, the radio and computational resources need to be allocated to each MU by taking into account the wireless channel condition and the computational power of MUs and MEC. In this paper, we propose an allocation scheme of the radio and computation resources to minimize the processing completion time of tasks which can be divided into local task and offload task. Local task is processed by each MU whilst offload task is processed by a MEC server. The processing completion time of the offload tasks are composed of three phases, uploading the tasks, processing the tasks at the MEC server, and returning the computation result from the MEC server to the MU. We first formulate the optimization problem to minimize the completion time of tasks. For the formulated optimization problem, we propose a two-step radio and computational resources allocation method which iteratively performs bisection search method and Johnson's algorithm. The numerical results elucidate that the proposed scheme can reduce the average total completion time by 33% compared to the conventional schemes.

Keywords Mobile edge computing (MEC), cellular network, resource allocation, optimization

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Computational Capability and Radio Resource Allocation for Mobile Edge Computing

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Background

- Mobile devices such as smartphone are inevitable in daily life
- Along with high performance of mobile devices, interest in mobile applications/services (Augmented reality etc.) has been increasing
- Problem in processing such applications: Necessity of high computing power
- The computing power of mobile devices are not yet to be sufficient to process heavy application tasks

➔ Applications are difficult to be processed on mobile devices only

Mobile edge computing (MEC) has attracted huge attention

◆ Mobile Edge Computing (MEC)
- A server with high computing power and storage capacity is deployed the edge of the radio access network (RAN)
- Server provides computing and storage capability to mobile devices

➔ It is possible to process heavy application task in short time

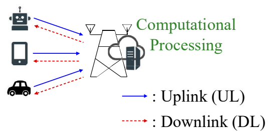

Fig. 1. MEC

Problem

◆ Requirement of MEC
- Low latency
  – Due to the increase of applications requiring real-time processing
- Effective utilization of limited radio and computation resources
  – Radio resources (such as frequency and time) necessary for communication
  – Computational resources (such as CPU) of MEC server for processing

Purpose

◆ Proposing an efficient resource allocation algorithm to minimize the processing completion time of application tasks, which consists of
- Uploading tasks from mobile users (MUs) to MEC server
- Processing the tasks at MEC server
- Downloading the computation result from MEC server to MUs

System Model

◆ Multiuser MEC system
- One MEC server with a computing power F_{mec} [CPU cycles/sec] at the BS
- U MUs: $\mathcal{U} = \{1, 2, \dots, U\}$ with computing power F_{local} [CPU cycles/sec] and dividable tasks
- Based on resource allocation result, each task is divided into
  – Local task: All or part of task that is processed by the local CPU
  – Offload task: All or part of task that is transmitted to MEC in UL, and whose computation results from MEC server are received in DL
- Scheduling among uploading, computing, and downloading tasks of MUs are executed in a time-division manner

◆ Task model (Parameters of task)
- Task size $D_u > 0$ [bits]
- Application type* $A_u > 0$ [CPU cycles/bit]
- Offload task size $l_{\mathrm{UL},u}$ [bits]
- Local task size $(D_u - l_{\mathrm{UL},u})$ [bits]
- Computation result size $f(l_{\mathrm{UL},u})$ [bits]

◆ Interference model
- The cell of interest is surrounded by interfering cells (Fig. 2)

* Describe the number of CPU cycles required to process one bit of task

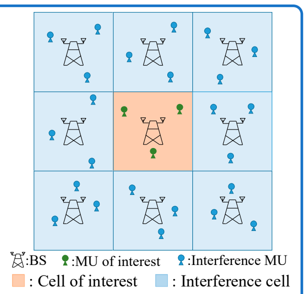

Fig. 2. Interference model

Proposed Algorithm

◆ Assignment of radio and computational resources by time-division manner
- It is essential to determine the local processing time, upload time, processing time at MEC and return time and scheduling time

➔ Executed by two-step iterative resource allocation method
  ➢ Time allocation ➔ Bisection search method
  ➢ Clock allocation ➔ Johnson's algorithm

◆ Bisection search determines the time durations of local processing and offload processing (uploading, processing at MEC, and downloading) for each MU so that the task completion time of each MU is minimized

◆ Johnson's algorithm schedules the sequence of offload processing of MUs

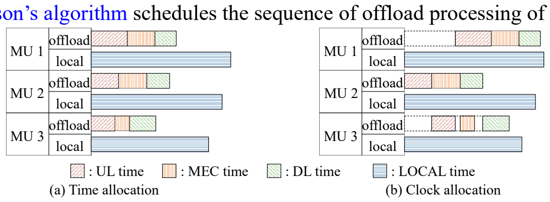

Fig. 3. Assign task time and clock of each MU

◆ Resource allocation method for minimizing total processing time
1. Local processing time, upload time, processing time at the MEC return time are determined using bisection search method
2. For the time obtained in step1, the order of each task is determined using the Johnson's algorithm
3. Processing completion time obtained by step2 (according to the feasibility condition) is evaluated
4. The minimum processing completion time is updated
5. Steps 1 to 3 are repeated until convergence**

**The difference between the processing time of the local task and the processing time of offload task becomes less than or equal to ε (very small value)

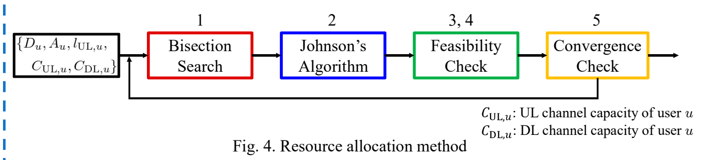

Fig. 4. Resource allocation method

[1] J. Guo, et al., "Energy-Efficient Resource Allocation for Multi-User Mobile Edge Computing", *in Proc. IEEE Global Commun. Conf.*, pp. 1-7, Singapore, Singapore, Dec. 2017.

Simulation & Conclusion

Table1. Simulation parameter [2]

Parameter		Value
Number of MUs in cell of interest		10, 20, 30, 40, 50, 100
BS	Number of BS	9 (cell of interest: 1)
	Coverage range	1000 [m] × 1000 [m]
Bandwidth		10 [MHz]
Transmission power	MU	23 [dBm]
	BS	43 [dBm]
Maximum data rate		6.0 [bps/Hz]
PSD of AWGN		–174 [dBm/Hz]
Shadowing deviation		6.0 [dB]
Local CPU F_{local}		$\{1, 2, \dots, 10\} \times 10^8$ [CPU cycles/s]
MEC CPU F_{mec}		10×10^9 [CPU cycles/s]
Data size D_u		$\{100, 150, \dots, 300\}$ [kbits]
Task type A_u		$\{5, 6, \dots, 15\} \times 10^2$ [CPU cycles/bit]
ε		0.0001
Computation result size***		$f(l_{\mathrm{UL},u}) = l_{\mathrm{UL},u}$

[2] H. Q. Le, et al., "Efficient Resource Allocation in Mobile edge Computation Offloading: Completion Time Minimization", *in Proc. IEEE ISIT*, pp. 2513-2517, Aachen, Germany, Jun. 2017.

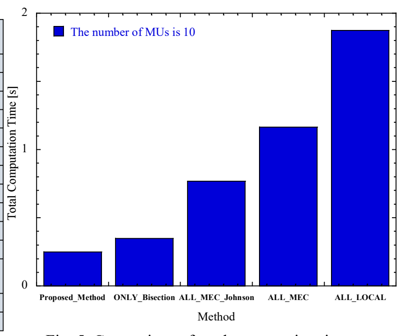

Fig. 5. Comparison of total computation time

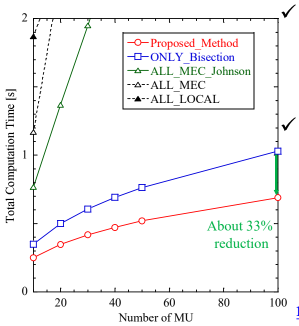

Fig. 6. Impact of the number of MUs

✓ Compared to processing all tasks locally, offloading tasks to MEC can greatly reduce computation time (Fig. 5, 6)

✓ When the number of MUs is 100, the proposed method reduces total computation time by about 33% compared to existing method (Fig. 6)

As the number of MUs increases, resources can be optimally allocated compared to existing method

Acknowledgement

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