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MULTIMEDIA CLOUD COMPUTING IN VEHICLES

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Abstract - Intelligent Transportation Systems (ITSs) means services to improve safety and traffic efficiency. For example, vehicle-to-vehicle communication for road safety. In ITSs, vehicles are equipped with a number of sensors which provide different functions like weather forecast, temperature, GPS etc. All these features make the drive better and smooth. As a result, these vehicles produce a large amount of multimedia related data, which is critical and delay-sensitive, and requires on-time processing. The standalone devices embedded in the vehicles cannot do the required fast-processing due to their limited computation facilities. Cost minimisation, Quality of Experience, and resource allocation are some more problems related to multimedia related content processing, which have arrived in recent times. Thus, the concept of merging cloud computing with vehicles has emerged. Still conventional cloud computing is not suitable for this critical and delay-sensitive multimedia related data. So a new computing paradigm called Multimedia Cloud Computing (MCC) has emerged. Thus, in this paper, a Dynamic Priority-based Efficient Resource Allocation and Computing scheme is proposed to overcome the above-mentioned issues.

Key Words - Multimedia, delay-sensitive, cluster

I. INTRODUCTION

These days automobile industry is focusing on autonomous or driverless vehicles a lot. In this, fast internet is a primary need. These smart vehicles can record videos, capture high resolution images, and process good amount of sensory data to ensure a smooth and comfortable drive. Furthermore, they can communicate and share information like road map images, road safety information and traffic load information with each other. Thus, these vehicles produce a huge amount of critical and delay-sensitive data which requires on-time processing for smooth QoE (Quality of Experience).

Cloud Computing (CC) is a new computing paradigm which helps in fast processing of data at low cost. It is an emerging computing paradigm that offers fast and high-speed computation facilities without installing any hardware. Thus, Cloud Computing (CC) is an efficient solution for processing large amount of data at low cost as no additional hardware is required.

Fig:1 Real-time and multimedia applications in vehicle

However, multimedia processing of vehicular data is critical and challenging as it requires fast processing and on-time response at reduced cost. Conventional CC is not suitable for critical and delay-sensitive multimedia related applications and services. Thus a new computing paradigm called Multimedia Cloud Computing (MCC) is introduced. MCC focuses on Quality of Experience (QoE).

So, we propose a Dynamic Priority-Based Efficient Resource Allocation and Computing (DP-ERACOM) scheme which is based on multimedia tasks priority.

This scheme processes the delay-sensitive and multimedia related computation for vehicular networks at reduced cost. In this scheme, each multimedia task is divided into 4 sub-tasks and resources (i.e., MCC resources) are allocated dynamically. The proposed scheme has 3 main computing and processing units:

1)Load Manager

2)Computing Cluster Unit

3)Transmission Unit

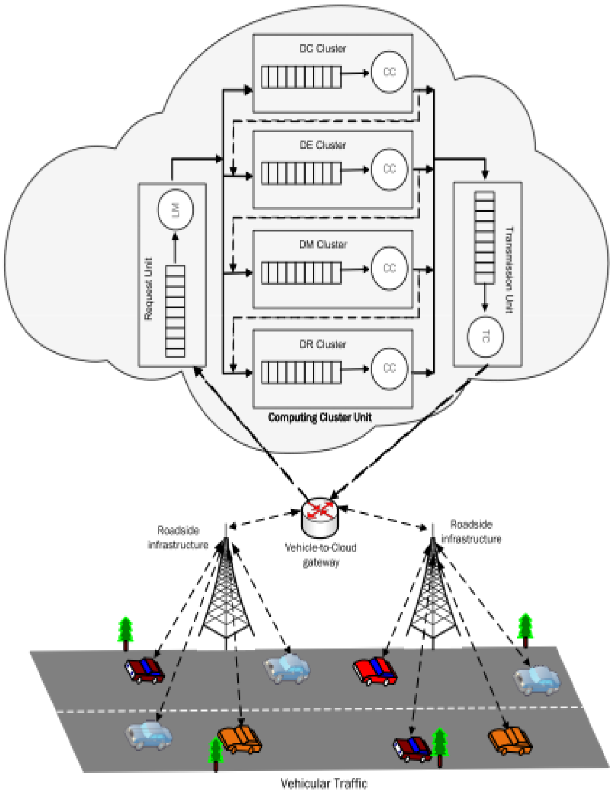

Fig: 2 Multimedia oriented cloud computing architecture for vehicles from [1]

The multimedia requests are received at request queue. These requests are forwarded to the Load Manager (LM), which processes the requests. The LM forwards the request to particular Computing Cluster (CC) after analysing the request. The CC further forwards the request to another CC or Transmission Unit (TU) based on the type of request. The TU then transmits the requests to a single or group of vehicles. All this is done on the basis of priority by using job queue (JQ). Each CC and TU consist of single job queue to contain multimedia requests in them.

II. DP-ERACOM

The DP-ERACOM scheme has three main components:

1)VMCC Architecture

2)Resource Allocation for VMCC

3)VMCC Queuing model

A) <u>VMCC Architecture</u>:

In this section, VMCC architecture will be discussed for processing multimedia related tasks. The processing of multimedia is divided into four steps:

(1) Conversion

(2) Extraction

(3) Matching

(4) Reconstruction

In the DP-ERACOM scheme, all these four computations are performed separately by 4 dedicated computing clusters (DCC). Each dedicated computing cluster is allocated computing resources dynamically as per need or load. Each dedicated computing cluster consists of a *priority queue* to maintain the priority of the multimedia requests.

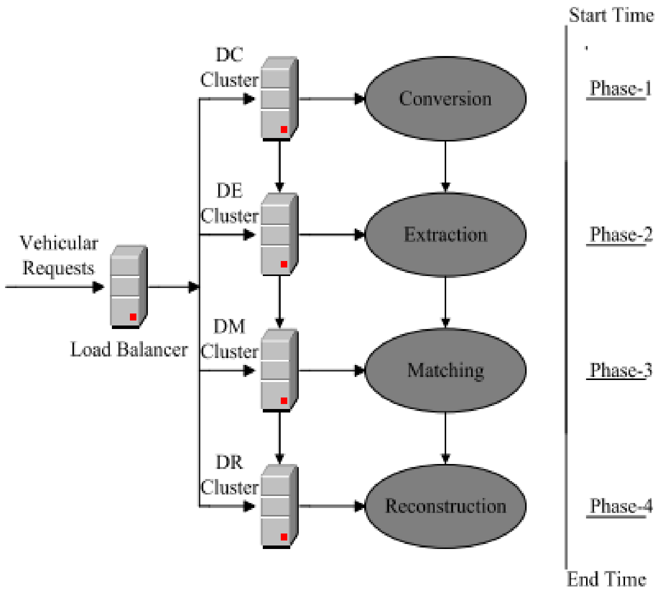

Fig:3 Task Level parallel Processing Procedure from [1]

The VMCC architecture is divided into four parts:

1)Request Unit (RU)

2)Load Manager

3)Computing Cluster Unit (CCU)

4)Transmission Unit (TU)

The vehicle submits its request to RU, which further forwards it to LM. The CCU has four sub-divisions:

(1) Dynamic Conversion Cluster (DCC)

(2) Dynamic Extraction Cluster (DEC)

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(3) Dynamic Matching Cluster (DMC)

(4) Dynamic Reconstruction Cluster (DRC)

Each dedicated computing cluster consists of a priority queue. The LM sends the multimedia tasks to the priority queue for computation on the basis of their priority. The TU may apply some conversions before forwarding the processed job to vehicle-to-cloud gateway, which forwards it to the requested vehicle.

B) VMCC Queuing Model

There are 3 types of job queues:

1) Requests queue in which the vehicle submits its media task

2) Computing or job queue which store vehicular media task for cloud processing

3) Transmission queue which store and hold the media tasks before forwarding them to their destinations

C) Resource Allocation for VMCC

Computing resources are allocated dynamically to the dedicated computing clusters (DCC) on the basis of load of the vehicular tasks. This ensures to minimize the computing cost. If there are more vehicular requests than the computing resources, then more computing resources are allocated to DCCs. Similarly, if the number of vehicular requests is less than the allocated resources, then computing resources are removed. This ensures minimization of cost, and a better QoE (Quality of Experience).

In Algorithm 1, between lines 1-4, initial assignments and analysations are made to incoming vehicular requests in time span αt. In lines 5-7, vehicular multimedia requests are analysed and sorted on the basis of priority. In lines 8-12, computing clusters are assigned resources on the basis of work load received in time αt. In lines 13-15, each multimedia task is assigned an appropriate CC, and is then put into its job queue for processing. In lines 16-22, CC processes the multimedia task and forwards it to the next computing unit or TU depending upon the nature of the task. Finally, in lines 23-25, the processed multimedia tasks are forwarded to the vehicular users simultaneously to improve the QoE and to meet the delay deadline of the task.

Algorithm 1 Priority-Based Task Scheduling and Processing Procedure

input : Global channel set N
output: Sorted Set of available channel K
1 Initialize request queue with $R_Q \leftarrow$ null
2 Assign collection time C_t with initial value α_t; $C_t \leftarrow \alpha_t$
3 Collect requests from vehicles till the expiry of α_t
4 LM analyzes the R_Q to estimate the total workload N
5 **for** $n_i \leftarrow 1$ **to** N **do**
6   /* Sort n_i based on priority value */
7 LM assigns computing resource χ_{α_t} to each computing cluster CC based on the value of total workload N
8 $DCC \leftarrow \chi_{\alpha_t}$
9 $DEC \leftarrow \chi_{\alpha_t}$
10 $DMC \leftarrow \chi_{\alpha_t}$
11 $DRC \leftarrow \chi_{\alpha_t}$
12 **for** $I \leftarrow 1$ **to** N **do**
13   /* LM sends multimedia task I into the priority queue P_Q of its appropriate CC */
14 **for** $J \leftarrow 1$ **to** N **do**
15   /* CC processes the multimedia task J */
16   **if** J *wants further processing step* **then**
17   Add J into the P_Q of next CC
18   **else**
19   Add J into the P_Q^T of TU
20 **for** $K \leftarrow 1$ **to** P_Q^T **do**
21   /* TU transmits processed multimedia task K to its intended vehicle(s) */

Algorithm1 from [1].

III. PERFORMANCE ANALYSIS

A) Experimental Setup

In our experimental setup, we are using Cloudsim to analyse the proposed scheme. Cloudsim is a java-based library model which is widely used for performing cloud related simulations. We divide our scenario into three units: (1) RU (2) CCU (3) TU. We perform simulations on images. We carried out simulations under different hardware settings (i.e., MIPS or Million Instructions per second, Ram, and number of CPUs) as in the following table:

S.No	RAM	MIPS	CPUs
Setting 1	4096 mb	2100	2
Setting 2	4096 mb	4200	1
Setting 3	4096 mb	2100	1

Table:1 from [1]

B) Performance Evaluation

The proposed scheme is compared with two schemes, baseline single cluster scheme and static resource allocation scheme. In baseline single cluster scheme, all four phases related to image processing are processed by a single cluster. In static resource allocation scheme, the resources are assigned to DCC at the start, and no periodic upgradation is done after. Comparison between the schemes is done on the following factors:

1) Quality of Experience

The QoE is measured using end-to-end time or SRT time. This is the time between vehicular multimedia request initiation till the vehicle receives its required response. If a vehicle receives required response in-time, then it experiences good QoE. And if a vehicle doesn't receive required response in-time, then it experiences low QoE. The QoE of the proposed system is:

$$T(tot) = T(sch) + T(com) + T(tra) \qquad (1)$$

For scheduling all priority-classes, the mean service response time given in [10] as follows:

$$T(sch) = (1/\mu)/1-(\lambda/\mu) \qquad (2)$$

where the scheduling rate is denoted as μ. The MST (Mean Service Time) for computing of all types priority is,

$$t(com)=\sum_{j=1}^{n}(\lambda i T(com))/\lambda \qquad (3)$$

where N is total multimedia tasks. The SRT for transmitting all multimedia results towards their intended vehicular user(s) is given in [10] as below:

$$T(tra)=\sum_{j=1}^{n}(\lambda j T(tra))/\lambda \qquad (4)$$

Thus, substituting all we get,

$$T(tot)= ((1/\mu)/1-(\lambda/\mu)) + (\sum_{j=1}^{n}(\lambda i T(com))/\lambda) + (\sum_{j=1}^{n}(\lambda j T(tra))/\lambda) \qquad (5)$$

If T(tot) of any multimedia request is below its given threshold, then end user(s) experience satisfactory QoE.

$$T(tot) < \text{Given threshold} \qquad (6)$$

If the above condition is not met, then more resources are needed to improve the QoE at the user(s) end.

2) Computing Cost

Providing desired QoE at reduced cost in cloud is quite challenging. Computing cost is directly proportional to the number of computing resources, like virtual machines allocated for a particular media task. Hence, more the number of computing resources, more the computing cost.

3) Simulation Results

In this section, we will see the simulation result of proposed scheme with static allocation scheme, and baseline single cluster allocation scheme.

In static resource allocation scheme, computing resources are allocated to computing clusters at the start. Further, no periodic upgradations are made. Whereas in the proposed scheme, computing resources are allocated to the dedicated computing clusters dynamically, which also leads to minimization in cost.

Fig 4(a)-4(d) show the performance results of the proposed scheme and static resource allocation scheme. Fig 4(a) presents SRT under configuration setting 1 in the above table. In this, VM has a processing speed of 2100 MIPS, 2CPUs and 4GB of RAM. It can be seen from the figure that the proposed scheme is better than the static resource allocation scheme. Fig5(d) shows simulation result in terms of number of computing resources (i.e., number of VMs).

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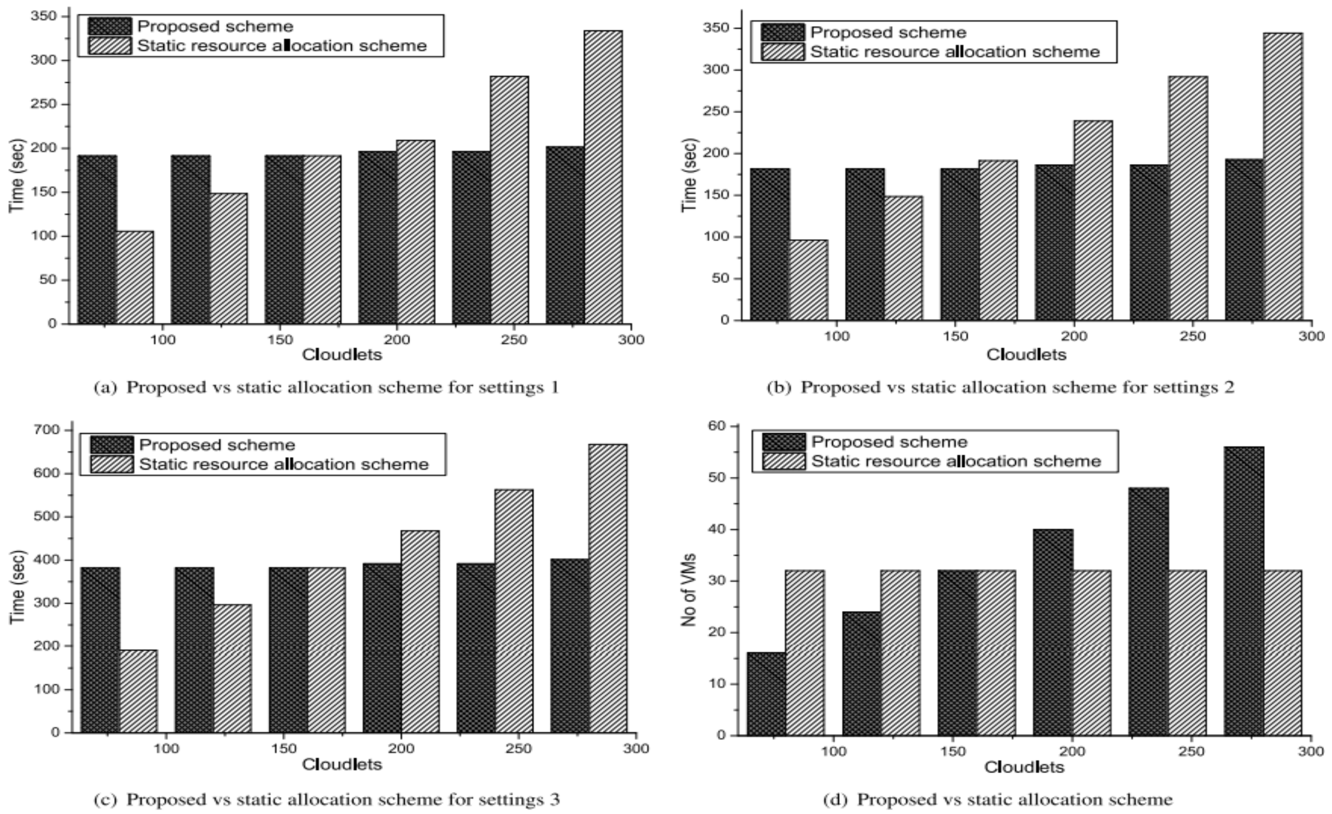


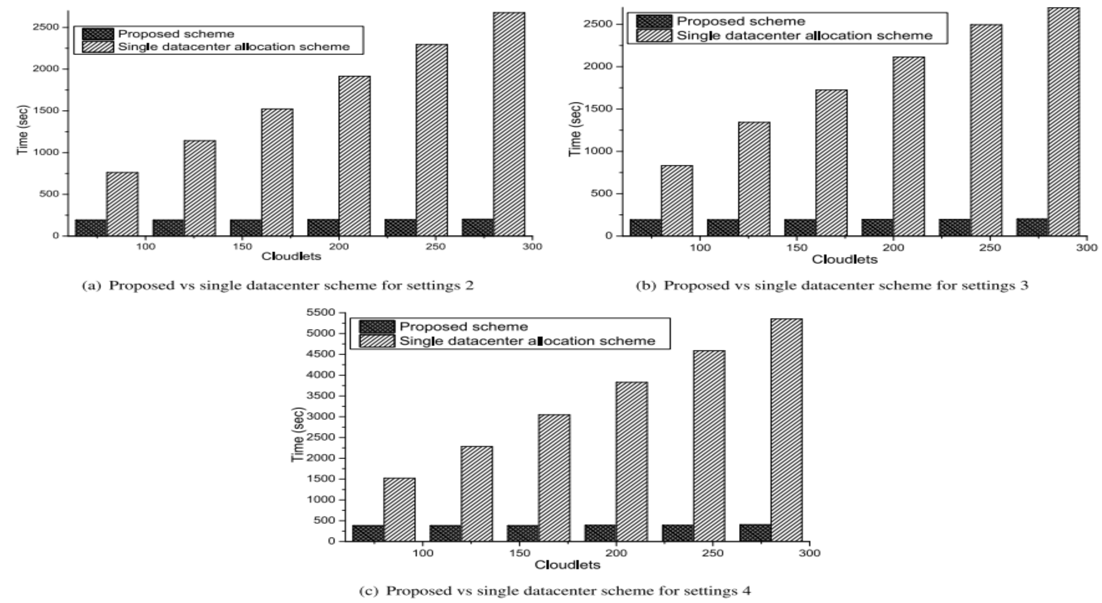
(a) Proposed vs static allocation scheme for settings 1

(b) Proposed vs static allocation scheme for settings 2

(c) Proposed vs static allocation scheme for settings 3

(d) Proposed vs static allocation scheme

Fig: 4 Proposed vs Static allocation scheme from [1]



(a) Proposed vs single datacenter scheme for settings 2

(b) Proposed vs single datacenter scheme for settings 3

(c) Proposed vs single datacenter scheme for settings 4

Fig: 5 Proposed vs Baseline Single cluster Allocation scheme from [1]

Fig 5(a)-5(d) show simulation results of SRT of proposed scheme with baseline single cluster scheme. It can be seen clearly that the proposed scheme outperforms the baseline single cluster scheme. But, SRT for baseline single cluster scheme increases with increase in the number of cloudlets. This is because in this scheme only one computing cluster is used to perform image processing. Where as in the proposed scheme, image processing is divided into four sub-tasks, for which there are four DCCs (dedicated computing cluster) for each task.

Hence, the proposed scheme is better than both single data-centre allocation scheme and static allocation scheme.

IV. CONCLUSION

Now-a-days, vehicles are being equipped with sensors, cameras, and many other devices to improve the QoE(Quality of Experience). All these devices produce a large amount multimedia related data. But all this data is critical and delay-sensitive. Also, the onboard standalone devices cannot perform fast processing on their own. So, another type of computing called Multimedia Cloud Computing (MCC) is used in vehicles. It ensures fast processing of vehicular multimedia data without installation of any hardware component. So, a Dynamic Priority-Based Efficient Resource Allocation and Computing scheme (DP-ERACOM) is proposed. This scheme addresses the challenges of fast response, Quality of Experience, and minimizing computing cost. In this scheme, multimedia tasks are divided into four sub-tasks, and are assigned to dedicated computing clusters (DCC) for processing. Moreover, computing resources are allocated dynamically as per load information. We compare the proposed scheme with two other schemes, baseline single cluster scheme and static resource allocation scheme. The simulation results clearly show that the proposed scheme outperforms the other two schemes.

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