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Comparative analysis of cloudlet completion time in time and space shared allocation policies during attack on smart grid cloud

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Abstract

Cloud computing has become the fastest growing field in IT industry and has benefited immensely the other fields like education, research, medical, banking, entertainment etc., through its unprecedented advantages. Another field named smart grid, due to its huge IT infrastructure and data management requirements, need cloud computing for its full realization especially in India. But, the data security issues have become major concern for cloud computing and smart grid industry. In this paper we have developed a cloud computing model for smart grid of India using CloudSim and have done comparative analysis of cloudlet completion time in time-shared and space-shared allocation policy in normal and attack conditions. This study will be helpful in designing intrusion detection systems for cloud.

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Keywords: cloud computing; smart grid; CloudSim; time-shared allocation policy; space-shared allocation policy.

1. Introduction

The need of fast, economical, convenient and on-demand access to computing resources has led to emergence of various computing paradigms. Grid computing and cluster computing came into being while edging closer to the objective of utility computing. The research culminated with the emergence of Cloud computing paradigm. Due to

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its unprecedented advantages, cloud computing has found its application in various fields, education, research, medical, banking, entertainment, to name a few. One more field that require its application is the power sector. The challenges like high transmission and distribution losses, AT&C losses, theft and demand-supply gap marked the inception of new system called smart grid. However, the smart grid has also got its own inherent characteristics. The intelligent monitoring sensors generate enormous heterogeneous, uncorrelated and unstructured data which need large number of scalable storage servers[1]. The lack of IT infrastructure and financial constraints in power sector are the primary challenges for full realization of complex smart grid in developing countries like India. However, the cloud computing model meets the requirement of data and computing intensive smart grid applications. Further, the history of cyber-attacks suffered by major cloud providers reveals that security and privacy issues in cloud computing have posed a major obstacle in developing the organization-cloud provider trust. The major concerns are integrity, availability, privacy, authorization, virtualization, data segregation, identity-management, loss of data, data lock-in, repudiation of information and network attacks[2].

Cloudlet completion time is an important parameter in detecting the attacks in a cloud[3]. In this paper the effect of space-shared and time-shared allocation policies on cloudlet completion time has also been studied. Rogue nodes have been installed in the cloud to generate attacks. The cloudlet completion time analysis has been done under normal and attack conditions with respect to number of cloudlets and cloudlet length. The remainder of this paper is organized as follows: Section 2 presents background and related work. Section 3 describes the design of experiment which discusses simulation modeling of smart grid of India under normal and attack conditions using CloudSim. The result of the simulation has been discussed in Section 4. Finally, Section 5 presents the conclusion.

2. Background and Related Work

Cloud computing is an evolving paradigm and has become a hotspot in both industry and academia. The National Institute of Standards and Technology (NIST) has defined cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction[4]. Smart grid or intelligent grid is a system of systems evolved through the integration of information & communication technology into electricity transmission and distribution networks. Smart grid is the next generation electricity grid which in contrast to traditional electricity system provides two-way flow of electricity and information to create an automated distribution and transmission network.

According to a recent IDCI survey, the top challenge for 74% of CIOs is cloud computing security. Various intrusion detection (IDS) and intrusion prevention systems (IPS)[5] have been developed to secure the cloud. IDS is an important aspect in cloud computing as without proper detection, analysis could be difficult and error-prone.

CloudSim is an open source simulation package that enables modeling, simulation and analysis of cloud behaviour under various deployment strategies[6]. CloudSim supports resource provisioning at two levels: first, at the host level and second, at the virtual machine (VM) level. At the host level, the host configuration is defined that indicates the amount of processing power that will be available to each VM. At the VM level, the VM configuration is defined that specifies the processing power to be allocated to cloudlets. At each level, CloudSim implements the time-shared or space-shared provisioning policies. When time-shared allocation is applied to both levels, the processing power is concurrently shared by the VMs and the shares of each VM are simultaneously divided among its task units. There are no queuing delays associated with task units. When the space-shared policy is applied at both host level and VM level, the allocation of VMs and cloudlets is done in following manner. At host level the processing power is exclusively used by first batch of VMs causing other VMs to wait till former's completion. Similarly, the VMs are used exclusively by set of tasks till their completion, causing other tasks to wait in queue[7].

There are various resource allocation policies which have been discussed by different researchers[8,9,10] but this work distinguishes itself from others in that, it addresses the unique requirements of the domain. Firstly, the smart grid infrastructure has control loops that tie the physical environment to the cyber physical system (CPS). Secondly, it provides comprehensive picture of cloudlet completion time of each cloudlet during two resource allocation

policies (time shared and space shared) in normal and attack conditions with respect to two important parameters namely number of cloudlets and cloudlet length.

3. Design of experiment

Power Grid Corporation Of India Limited (POWERGRID), the Central Transmission Utility (CTU) of the country under Ministry of Power is one amongst the largest Power Transmission utilities in the world. It has intra city network in 68 cities and point of presence in approximately 178 cities[11]. The cloud is created on cloudSim for POWERGRIDs smart grid network. In the experiments, service from 1 CSP or 1 Datacenter is taken. There are 2 hosts/servers created on datacenter where each host has configuration of 16 GB RAM, 100000 GB of storage and bandwidth of 1000Gbps. Each VM has characteristic of 250 MIPS, 1 Gbps bandwidth and image size of 256 MB. The cloudlets have the characteristics of 300 MB file size and output file size of 300 MB. The parameters: VM RAM, no. of cloudlets and cloudlet length are varied throughout the experiments. The effect of these parameters under time-shared and space-shared allocation policies have been studied under normal and attack conditions.

4. Result and discussion

Table 1 shows the cloudlet completion time of cloudlets with respect to variation in no. of cloudlets (n) under normal conditions when space-shared allocation policy is applied. At n= 68 maximum of 52.94% of cloudlets complete their execution in time interval (1-500)s. As n is increased from 78 to 98, equal percentage of cloudlets complete their tasks in time interval (1-500)s and (501-1000)s, the percentage being 46.15%, 40.91% and 36.73% for n=78, 88 and 98 respectively. As n is increased from 108 to 128, equal percentage of cloudlets complete their tasks in time interval (1-500)s, (501-1000)s and (1001-1500)s, the percentage being 33.33%, 30.51% and 28.13% for n=108, 118 and 128 respectively. Table 3 depicts the cloudlet completion time of cloudlets with respect to variation in no. of cloudlets (n) under attack conditions when time-shared allocation policy is applied. For n= 68 to 108, maximum of cloudlets complete their execution in time interval (1-500)s. At n= 128, maximum of cloudlets complete their execution in (500-1000) and (3501-4000)s. Table 4 depicts the cloudlet completion time of cloudlets with respect to variation in no. of cloudlets (n) under attack conditions when space-shared allocation policy is applied. Table 5 depicts the cloudlet completion time of cloudlets with respect to variation in cloudlet length (l) under normal conditions when time-shared allocation policy is applied. When l=40000 instructions, maximum no. of cloudlets (64.18%) complete their execution in time interval (1-400)s. Maximum of 81.82%, 82.35%, 82.35%, 55.88%, 52.94% complete their execution at l= 50000, 60000, 70000, 80000 and 90000 instructions respectively in interval (401-800)s. Table 6 depicts the cloudlet completion time of cloudlets with respect to variation in cloudlet length (l) under normal conditions when space-shared allocation policy is applied. As 'l' is increased from 50000 to 90000 maximum of 79.41% cloudlets complete their execution in interval (401-800)s. Further, as 'l' is increased from 90000 to 140000 maximum of 79.41% cloudlets complete their execution in interval (801-1200)s. Table 7

Table 1. No. of Cloudlets VS Time (Time Shared) under Normal Conditions

No. of Cloudlets	(1-500)	(500-1000)	(1-500)%	(500-1000)%
68	68	0	100.00	0.00
78	78	0	100.00	0.00
88	79	9	89.77	10.23
98	74	24	75.51	24.49
108	69	39	63.89	36.11
118	64	54	54.24	45.76
128	45	83	35.16	64.84

depicts the cloudlet completion time of cloudlets with respect to variation in cloudlet length (l) under attack conditions when time-shared allocation policy is applied. Table 8 depicts the cloudlet completion time of cloudlets with respect to variation in cloudlet length (l) under attack conditions when space-shared allocation policy is applied. At l= 40000 max. of 35.29% of cloudlets complete their execution in (1-400)s. At 1= 50000, 60000 and 70000, max. of 35.29% of cloudlets complete their execution in (401-800), (401-800) and (801-1200)s respectively.

Table 2. No. of Cloudlets VS Time (Space Shared) under Normal Conditions

	(1-500)	(501-1000)	(1001-1500)	(1501-2000)	(1-500)%	(501-1000)%	(1001-1500)%	(1501-2000)%
68	36	32	0	0	52.94%	47.06%	0.00%	0.00%
78	36	36	6	0	46.15%	46.15%	7.69%	0.00%
88	36	36	16	0	40.91%	40.91%	18.18%	0.00%
98	36	36	26	0	36.73%	36.73%	26.53%	0.00%
108	36	36	36	0	33.33%	33.33%	33.33%	0.00%
118	36	36	36	10	30.51%	30.51%	30.51%	8.47%
128	36	36	36	20	28.13%	28.13%	28.13%	15.63%

Table 3. No. of Cloudlets VS Time (Time Shared) under Attack Conditions

	(1-500)	(500-1000)	(1501-2000)	(3001-3500)	(3501-4000)	(1-500)	(500-1000)	(1501-2000)	(3001-3500)	(3501-4000)
68	58	0	10	0	0	85.29%	0.00%	14.71%	0.00%	0.00%
78	58	0	20	0	0	74.36%	0.00%	25.64%	0.00%	0.00%
88	58	0	30	0	0	65.91%	0.00%	34.09%	0.00%	0.00%
98	46	13	31	8	0	46.94%	13.27%	31.63%	8.16%	0.00%
108	58	0	22	28	0	53.70%	0.00%	20.37%	25.93%	0.00%
118	38	20	12	28	20	32.20%	16.95%	10.17%	23.73%	16.95%
128	18	40	2	28	40	14.06%	31.25%	1.56%	21.88%	31.25%

Table 4. No. of cloudlets VS Time (Space shared) under Attack conditions

	(1-500)%	(501-1000)%	(2001-2500)%	(3501-4000)%	(4001-4500)%	(5001-5500)%	(5501-6000)%	(7001-7500)%	(8501-9000)%	(10001-10500)%
68	52.94%	32.35%	14.71%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
78	46.15%	28.21%	15.38%	2.56%	7.69%	0.00%	0.00%	0.00%	0.00%	0.00%
88	40.91%	25.00%	13.64%	2.27%	11.36%	2.27%	4.55%	0.00%	0.00%	0.00%
98	36.73%	22.45%	12.24%	2.04%	10.20%	2.04%	10.20%	4.08%	0.00%	0.00%
108	33.33%	20.37%	11.11%	1.85%	9.26%	1.85%	9.26%	11.11%	1.85%	0.00%
118	30.51%	18.64%	10.17%	1.69%	8.47%	1.69%	8.47%	10.17%	10.17%	0.00%
128	28.13%	17.19%	9.38%	1.56%	7.81%	1.56%	7.81%	9.38%	9.38%	7.81%

Table 5. Cloudlet Length VS Time (Time Shared) under Normal conditions

	(1-400)	(401-800)	(801-1200)	(1201-1600)	(1-400)	(401-800)	(801-1200)	(1201-1600)
40000	43	24	0	0	64.18%	35.82%	0.00%	0.00%
50000	12	54	0	0	18.18%	81.82%	0.00%	0.00%
60000	12	56	0	0	17.65%	82.35%	0.00%	0.00%
70000	12	56	0	0	17.65%	82.35%	0.00%	0.00%
80000	6	38	24	0	8.82%	55.88%	35.29%	0.00%
90000	6	36	26	0	8.82%	52.94%	38.24%	0.00%
100000	5	7	56	0	7.35%	10.29%	82.35%	0.00%
110000	0	12	56	0	0.00%	17.65%	82.35%	0.00%
120000	0	12	32	24	0.00%	17.65%	47.06%	35.29%
130000	0	12	32	24	0.00%	17.65%	47.06%	35.29%
140000	0	12	30	26	0.00%	17.65%	44.12%	38.24%

Table 6. Cloudlet Length VS Time (Space Shared) under Normal Conditions

	(1-400)	(401-800)	(801-1200)	(1601-2000)	(2001-2400)	(1-400)	(401-800)	(801-1200)	(1601-2000)	(2001-2400)
40000	58	0	0	10	0	85.29%	0.00%	0.00%	14.71%	0.00%
50000	4	54	0	10	0	5.88%	79.41%	0.00%	14.71%	0.00%
60000	4	54	0	10	0	5.88%	79.41%	0.00%	14.71%	0.00%
70000	4	54	0	10	0	5.88%	79.41%	0.00%	14.71%	0.00%
80000	4	54	0	10	0	5.88%	79.41%	0.00%	14.71%	0.00%
90000	4	54	0	10	0	5.88%	79.41%	0.00%	14.71%	0.00%
100000	0	4	54	0	10	0.00%	5.88%	79.41%	0.00%	14.71%
110000	0	4	54	0	10	0.00%	5.88%	79.41%	0.00%	14.71%
120000	0	4	54	0	10	0.00%	5.88%	79.41%	0.00%	14.71%
130000	0	4	54	0	10	0.00%	5.88%	79.41%	0.00%	14.71%
140000	0	4	54	0	10	0.00%	5.88%	79.41%	0.00%	14.71%

Table 7. Cloudlet Length VS Time (Time Shared) under Attack Conditions

	(1-400)	(401-800)	(801-1200)	(1201-1600)	(1601-2000)	(2001-2400)	(2401-2800)	(2801-3200)	(3201-3600)
40000	35.29%	52.94%	11.76%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
50000	35.29%	35.29%	29.41%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
60000	17.65%	35.29%	35.29%	11.76%	0.00%	0.00%	0.00%	0.00%	0.00%
70000	17.65%	17.65%	35.29%	17.65%	11.76%	0.00%	0.00%	0.00%	0.00%
80000	17.65%	17.65%	17.65%	35.29%	11.76%	0.00%	0.00%	0.00%	0.00%
90000	17.65%	17.65%	17.65%	17.65%	17.65%	11.76%	0.00%	0.00%	0.00%
100000	17.65%	17.65%	17.65%	17.65%	17.65%	11.76%	0.00%	0.00%	0.00%

110000	0.00%	17.65%	17.65%	35.29%	0.00%	17.65%	11.76%	0.00%	0.00%
120000	0.00%	17.65%	17.65%	17.65%	17.65%	17.65%	0.00%	11.76%	0.00%
130000	0.00%	17.65%	17.65%	17.65%	0.00%	17.65%	17.65%	11.76%	0.00%
140000	0.00%	17.65%	17.65%	0.00%	17.65%	17.65%	17.65%	0.00%	11.76%

Table 8. Cloudlet Length VS Time (Space Shared) under Attack Conditions

	(1-400)	(401-800)	(801-1200)	(1201-1600)	(1601-2000)	(2001-2400)	(2401-2800)	(2801-3200)	(3201-3600)	(3601-4000)	(4001-4400)	(4401-4800)
40000	35.29%	35.29%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%	0.00%	0.00%	0.00%	0.00%
50000	17.65%	35.29%	32.35%	0.00%	0.00%	0.00%	14.71%	0.00%	0.00%	0.00%	0.00%	0.00%
60000	17.65%	35.29%	17.65%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%	0.00%	0.00%	0.00%
70000	17.65%	17.65%	35.29%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%	0.00%	0.00%	0.00%
80000	17.65%	17.65%	17.65%	17.65%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%	0.00%	0.00%
90000	17.65%	17.65%	17.65%	17.65%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%	0.00%	0.00%
100000	0.00%	17.65%	17.65%	17.65%	17.65%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%	0.00%
110000	0.00%	17.65%	17.65%	17.65%	17.65%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%	0.00%
120000	0.00%	17.65%	17.65%	17.65%	17.65%	0.00%	14.71%	0.00%	11.76%	0.00%	2.94%	0.00%
130000	0.00%	17.65%	17.65%	17.65%	0.00%	17.65%	14.71%	0.00%	0.00%	11.76%	2.94%	0.00%
140000	0.00%	17.65%	17.65%	0.00%	17.65%	17.65%	0.00%	14.71%	0.00%	11.76%	0.00%	2.94%

4. Conclusion

The experiments show that space shared allocation policy takes more time to execute the cloudlets in normal conditions as well as in attack conditions when compared with time-shared allocation policy in case of variation in no. of cloudlets. The same trend has been observed in case of variation in cloudlet length.

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