

Department of Computer Science



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Swarm Memory

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Executive Summary

1 Introduction

Swarm robotics/intelligence/mechanics is becoming an increasingly important area of research for society as the world moves towards a distributed technology future. Swarm intelligence can be viewed as distributed problem solving [2, 5], this is ever becoming more and more relevant as computer systems start to level out in terms of individual performance [7] and parallelism is embraced to be able to satisfy the demand of the age of big data [9]. Swarm mechanics and robotics are on the rise in industry, as society's pace increases and manual labour is automated out, whether its drone delivery to impatient customers or mapping areas in dangerous zones [1].

Another area of swarm robotics research is distributed and local memory of swarm like agents. This area of research has gone down a route more to do with the optimisation of distributed problem solving algorithms rather than practical applications of storage of abstract ideas as a collective. Examples of this is from my understanding there is no research into collective memory on swarm like agents. This research is invaluable due to applications like mapping of dangerous area [2], being able to handle loss of agents and collect data on agents with limited memory. An explanation for this to be a less developed area of study is due to subjects like cloud based and raid based storage systems.

Storage of data on an ever changing network of storage devices is a hard task to complete, handling loss of connection between different servers, reliability to access of data and handling loss of services whether it be non-correlated or correlated failures [9]. This is very applicable to swarm memory handling of data however must be adapted, this is due to current algorithms such as raid not really being designed for highly dynamic systems such as a swarm system. However there are promising papers in this field that suggest approaches that can be adapted with few modifications to be applicable to a swarm based system [10].

The objectives of this report is to merge two different areas of study into one by using different knowledge of each area to create a suitable storage policy for swarm like agents to store collective memories of abstract ideas, then to perform analysis on a variety of simulations to explore the capabilities of said storage policy.

1 Introduction

// Talk about the sections of the report once completed.

2 Literature Review

This chapter will review two areas of relevancy to the project proposed, these are Cloud/Backup storage policys/schemes and Swarm robotics. Ideas and concepts from both areas will have to be relied upon for the completion/design of the storage policy.

2.1 Cloud/Backup storage policys/schemes

As most things in computer science, this area of study used to be very simple, with small datawarehouses and backups on to a medium like magnetic tape following something like a grandfather, father, son method. However as the years have progressed, technology has become much more complex requiring larger files of data to be stored and to be accessed frequently leading to the need of more complex backup systems to provide availability and longevity of data stored. A big component for the complexity of these algorithms other than providing a service better than competitors is the Legal Services Act. 2007 [11], which makes companies cloud storage solutions to have to be reliable and fast into collection of data for users.

Most algorithms used in production are called random replication policys [9] where data is partitioned and randomly distributed among other storage devices usually on different racks of the datacenter. This is an efficient design policy for handling non-correlated errors however lacks the robustness against correlated errors. These algorithms are good for longer term data storage with average popularity in terms of need for collection of that data.

Some of the problems arisen from random replication policys has spawned a new design policys, of which can handle correlated, non-correlated errors. Usually these policys also account for the demand of such item [9, 10]. To tackle these problems two approaches have been taken, one is to go from a higher level approach where you have a sort of manager which chooses which items to replicate and where based off demand, knowledge of other replications and outside factors [9, 12], not as suitable in terms of actual data changes but scheme changes of servers [13]. Working versions of these over a cloud service are tied together usually with a "Distributed

2 Literature Review

key-value store" [14] where you have these key-value pairs on multiple devices on a network and duplication only leads to more fault tolerance of the data stored.

Another way to handle this which doesn't rely on a more privileged node or duplicated data, and creates a distributed system is by having something like "SKUTE" as proposed in [10]. This is where all individual key-values have a their own choice on what to do in a distributed system. This is described as four sections which are Migration, Suicide, Replication and Nothing; where Migration is the moving of data to lower costing and more redundant servers, Suicide is the removal of itself usually based on amount of duplicates and uses something like Paxos [15] to decide if it should suicide and Replication where it decides that it is being used enough to need to be replicated or there is possibly no other duplicates of this data.

An algorithm like "SKUTE" [10] will be suited best for swarm like agents due to the distributed nature of a swarm, and not wanting to have a static/temporary leader due to issues like communication bottleneck, power loss in the swarm near the leader due to flow of information to the leader, loss of leader (mainly only if static) [1, 5]. Also some of the main reasons for using swarm robotics is the inherent parallel nature that they bring to the table, therefore creating leader based algorithms are not in the spirit of the design of a homogenous swarm, unlike a heterogeneous swarm.

Another area of study which is highly static is storage of data on local disks and how to keep either backups for disk failure or/and improve write performance onto disks, rather than just duplicating data like as described above. An example scheme for this is something like RAID, which have different levels based off the type of attributes that you may need [?]. In terms of cloud based storage RAID arrays are used commonly internally rather than externally to a different NAS or storage server. This is usually because we will have the guarantees of RAID for disk failures if they acquire and for example a server goes down we have the above replication schemes to be able to handle that. Therefore leading to having RAID arrays across multiple nodes to be sort of redundant. However with using a parity [8] based higher level scheme you will get space savings on the duplication of data, this is harder to implement though and most likely not needed due to servers that are lost due to power outages usually come back on pretty soon also known as something like a concurrent-failure.

// TODO: Say what a correlated and non correlated failure is

2.2 Swarm robotics

3 Motivation

4 Methodology/Design

5 Conclusion

A Some apendix

B Another apendix

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