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On the Optimal Tuning and Placement of FEC Codecs within Multicasting Trees for Resilient Publish/Subscribe Services in Edge-IoT architectures

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Abstract

Publish/subscribe services represent the key choice to glue together the huge amount of heterogeneous devices available within the Internet of Things, by making them interoperable at a large scale through mediation systems and facilities available in the cloud. In such a scenario, several optimizations have been introduced in the architectural layout by pushing parts of the service intelligence away from centralized points to the logical extremes, namely the edge, of the infrastructure, according to the edge computing paradigm. Such services can establish tree-based overlays among the involved nodes, and are used on top of unreliable networks, where packets have a non-negligible probability to be lost. In order to reduce such losses affecting wide area communications, the need to move data towards the cloud has been reduced by placing more frequent computations at the edge of the infrastructure, nearer to data sources, according to the edge computing paradigm. However, this is not enough and, in order to provide resilient and reliable communications, publish/subscribe implementations have been equipped with means to achieve loss-tolerance, which unfortunately have been proved to be ineffective (by lacking having end-to-end guarantees) and inefficient (by compromising the communication performance). In this paper, we identify Forward Error Correction as a suitable method to have efficient and effective loss tolerance within multicast trees, and describe how dealing with its issues by having the interior nodes within the multicast trees to generate spatial redundancy in addition to the one produced by the root. The decision of which nodes on the network edge must generate the additional redundancy and how many additional packets must be forwarded has been approached by using a Single-Leader Multi- Follower Game. Such an approach has been empirically assessed and compared with a centralized one, represented by a genetic algorithm, and with gossiping, so as to show the achievement of optimal decisions.

Keywords: Publish/subscribe, Game Theory, Forward Error Correction, Sensor Communications, Single-Leader Multi- Follower Game.

1. Introduction

The Internet is progressively transforming into a huge-scale complex ubiquitous and pervasive computing eco-system, integrating billions of fixed and mobile networked objects deployed over wide geographic areas, that continuously produce and consume significant amounts of data, and are mutually interconnected according to several communication paradigms and technologies grouped under the Internet of Things (IoT) umbrella. In this scenario, the flexibility of cloud-based architectures, together with the recent advancements in the area of distributed computing and data storage give the opportunity of shifting the more computationally expensive and storage-demanding operations to the cloud in order to benefit of scale economies, as well as increased flexibility and elasticity in the resource management. However, such a shift introduces

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