Distributed Data Stream Processing and Edge Computing: A Survey on Resource Elasticity and Future Directions

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Distributed Data Stream Processing and Edge Computing: 
A Survey on Resource Elasticity and Future Directions

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Abstract
Under several emerging application scenarios, such as in smart cities, operational monitoring of large infrastructure, wearable assistance, and Internet of Things, continuous data streams must be processed under very short delays. Several solutions, including multiple software engines, have been developed for processing unbounded data streams in a scalable and efficient manner. More recently, architecture has been proposed to use edge computing for data stream processing. This paper surveys state of the art on stream processing engines and mechanisms for exploiting resource elasticity features of cloud computing in stream processing. Resource elasticity allows for an application or service to scale out/in according to fluctuating demands. Although such features have been extensively investigated for enterprise applications, stream processing poses challenges on achieving elastic systems that can make efficient resource management decisions based on current load. Elasticity becomes even more challenging in highly distributed environments comprising edge and cloud computing resources. This work examines some of these challenges and discusses solutions proposed in the literature to address them.

Keywords:
Big Data, Stream processing, Resource elasticity, Cloud computing

1. Introduction
The increasing availability of sensors, mobile phones, and other devices has led to an explosion in the volume, variety and velocity of data generated and that requires analysis of some type. As society becomes more interconnected, organisations are producing vast amounts of data as result of instrumented business processes, monitoring of user activity [1, 2], wearable assistance [3], website tracking, sensors, finance, accounting, large-scale scientific experiments, among other reasons. This data deluge is often termed as big data due to the challenges it poses to existing infrastructure regarding, for instance, data transfer, storage, and processing [4].

A large part of this big data is most valuable when it is analysed quickly, as it is generated. Under several emerging application scenarios, such as in smart cities, operational monitoring of large infrastructure, and Internet of Things (IoT) [5], continuous data streams must be processed under very short delays. In several domains, there is a need for processing data streams to detect patterns, identify failures [6], and gain insights.

Several stream processing frameworks and tools have been proposed for carrying out analytical tasks in a scalable and efficient manner. Many tools employ a dataflow approach where incoming data results in data streams that are redirected through a directed graph of operators placed on distributed hosts that execute algebra-like operations or user-defined functions. Some frameworks, on the other hand, discretise incoming data streams by temporarily storing arriving data during small time windows and then performing micro-batch processing whereby triggering distributed computations on the previously stored data. The second approach aims at improving the scalability and fault-tolerance of distributed stream processing tools by handling straggler tasks and faults more efficiently.

Also to improve scalability, many stream processing frameworks have been deployed on clouds [7], aiming to benefit from characteristics such as resource elasticity. Elasticity, when properly exploited, refers to the ability of a cloud to allow a service to allocate additional resources or release idle capacity on demand to match
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