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Methods and Techniques for Processing Streaming Big Data in Datacentre Clouds

IEEE Transactions on Emerging Topics in Computing

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Internet of Things (IoT) is a part of Future Internet and comprises many billions of Internet connected Objects (ICOs) or ‘things’ where things can sense, communicate, compute and potentially actuate as well as have intelligence, multi-modal interfaces, physical/virtual identities and attributes. ICOs can include sensors, RFIDs, social media, actuators (such as machines/equipments fitted with sensors) as well as lab instruments (e.g., high energy physics synchrotron), and smart consumer appliances (smart TV, smart phone, etc.). The IoT vision has recently given rise to IoT big data applications that are capable of producing billions of data stream and tens of years of historical data to support timely decision making. Some of the emerging IoT big data applications, e.g. smart energy grids, syndromic biosurveillance, environmental monitoring, emergency situation awareness, digital agriculture, and smart manufacturing, need to process and manage massive, streaming, and multi-dimensional (from multiple sources) data from geographically distributed data sources.

Despite recent technological advances of the data-intensive computing paradigms (e.g. the MapReduce paradigm, workflow technologies, stream processing engines, distributed machine learning frameworks) and datacentre clouds, large-scale reliable system-level software for IoT big data applications are yet to become commonplace. As new diverse IoT applications begin to emerge, there is a need for optimized techniques to distribute processing of the streaming data produced by such applications across multiple datacentres that combine multiple, independent, and geographically distributed software and hardware resources. However, the capability of existing data-intensive computing paradigms is limited in many important aspects such as: (i) they can only process data on compute and storage resources within a centralised local area network, e.g., a single cluster within a datacentre. This leads to unsatisfied Quality of Service (QoS) in terms of timeliness of decision making, resource availability, data availability, etc. as application demands increase; (ii) they do not provide mechanisms to seamlessly integrate data spread across multiple distributed heterogeneous data sources (ICOs); (iii) lack support for rapid formulation of intuitive queries over streaming data based on general purpose concepts, vocabularies and data discovery; and (iv) they do not provide any decision making support for selecting optimal data mining and machine algorithms, data application programming frameworks, and NoSQL database systems based on nature of the big data (volume, variety, and velocity). Furthermore, adoption of existing datacentre cloud platform for hosting IoT applications is yet to be realised due to lack of techniques and software frameworks that can guarantee QoS under uncertain big data application behaviours (data arrival rate, number of data sources, decision making urgency, etc.), unpredictable datacentre resource conditions (failures, availability, malfunction, etc.) and capacity demands (bandwidth, memory, storage, and CPU cycles). It is clear that existing data intensive computing paradigms and related datacentre cloud resource provisioning techniques fall short of the IoT big data challenge or do not exist. Topics of interest include, but are not limited to:

- Programming abstractions for extending existing data intensive computing paradigms to multiple datacentres
- Technical foundations for selection of data mining and machine learning algorithms
- Streaming data query and indexing systems based on semantic web concepts
- IoT big data application specific ontology models for capturing heterogeneous data from multiple sources
- Decentralised data flow optimisation and management techniques across multiple datacentres
- Techniques for petabyte efficient no-SQL query-based IoT big data processing
- QoS optimized parallel data analytic techniques beyond traditional relational database systems
- Knowledge driven, predictive datacentre resource allocation and provisioning for streaming data
- Innovative IoT big data application use cases
- Techniques for providing a secure end-to-end connection between users and data sources

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