**Resource and Service Management in Fog Computing**

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**Introduction**

Insufficiency of cloud for new generation applications e.g. IoT:
- 6 Vs of Big Data: Volume, Velocity, Veracity, Variety, Variability, and Value.
- Lack of support for latency-critical applications.
- Insufficient support for bandwidth-intensive applications.

**Fog Computing**
- Heterogeneous fog nodes deployed closer to data sources.
- Insufficiency of cloud for new generation applications e.g. IoT:
  - Limited scalability and insufficient processing power.

**Proposed architecture for the organization of heterogeneous fog nodes**
- Supports multi-layered hierarchy of heterogeneous fog nodes.
- Facilitates location-sensitive, context-aware applications and those of only local value.
- Placement of fog nodes at unmanaged sites results in lower reliability.

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**Initial Service deployment in Fog**

- Proposed Voronoi structure based geo-partitioning of a given area with fog nodes as sites.
- Area of influence of fog node is defined by its Voronoi region.
- Fog node assigned to a region is best choice to serve service requests from co-located IoT devices and users.

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**Resource Management in Fog - Challenges**

- Heterogeneous fog nodes with varied resource configurations.
- Number of nodes in a fog environment is of several orders of magnitude more than that in a cloud.
- Widely dispersed over large geographic areas, possibly individually at unmanaged sites.
- Dynamic fog environment resulting from energy-constrained nature of fog nodes, node mobility, and frequent node join/leave to support variable local workload.
- Significance of geolocation of fog nodes to support location-sensitive, context-aware applications and those of only local value.
- Placement of fog nodes at unmanaged sites results in lower reliability.

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**Service Management in Fog - Challenges**

- Energy-constrained nature and mobility of fog nodes result in increased frequency of service deployment requests.
- Mobility of IoT devices, users, and fog nodes necessitate frequent migration of application services and data to other fog nodes.
- Incomplete knowledge of system state, renders centralized solution approaches infeasible.
- Data dispersed over different compute and storage nodes.
- Significance of individual instances of a given service based on the hosting fog node geolocation.
- Cost-optimal deployment of services balancing the utilization of low cost cloud and higher layer fog nodes as well as high cost lower layer fog nodes.

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**References**


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**Preliminary Results**

- Hypothetical smart city dataset with 781 prospective fog nodes includes five types of fog nodes, each represented by a fog layer, and vary in resource configuration and mobility characteristics.
- Fog nodes belonging to each layer represented by a unique color.
- Nodes belonging to same fog layer are grouped into Puddles using Agglomerative Complete Linkage Hierarchical Clustering approach.
- Parent-child relationships among Puddles in adjacent layers are formed using Complete Linkage method.
- Hafa facilitates fully distributed resource management and allocation, using local system state knowledge.

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**Work in Progress**

- Working on research problems (assuming pre-deployed fog infrastructure):
  - Application service placement in fog satisfying resource and QoS requirements as well as optimizing node utilization, network utilization, service execution cost, energy consumption, performance, availability, and load balancing.
  - Application service migration in fog considering similar factors as above while minimizing impact on user-perceived performance.
- Developing PuddleSim (Simulator):
  - Event-based simulator extended from FogSim and CloudSim.
  - Supports mobility of IoT devices, fog nodes, and users.
  - Supports multi-layered hierarchy of heterogeneous fog nodes.
  - Supports organization of fog nodes into Puddles.
  - Facilitates testing of various service deployment strategies and application environments.