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Joint Base Station Selection and Adaptive Slicing in Virtualized Wireless Networks

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I. Motivation

Resource sharing has been a common practice for Mobile Network Operators (MNOs) to decrease the capital and operational expenditures of deploying and maintaining their cellular networks. Roaming agreements and passive infrastructure sharing, such as the sharing of physical sites, tower masts, and power, saved expenditures leading to motivation in more active resource sharing, such as the reuse of backhaul and the sharing of radio access networks. This has led to wireless virtualization, a promising approach for efficient sharing of radio resources in next-generation mobile networks.

Our work focuses on the problem of resource allocation for virtualized wireless network (VWN) construction. We use a framework based on the Network without Borders (NwoB) paradigm, which introduces a service-oriented concept as a natural motivation for virtualization in mobile wireless networks (MWNs).

II. VWN Architecture

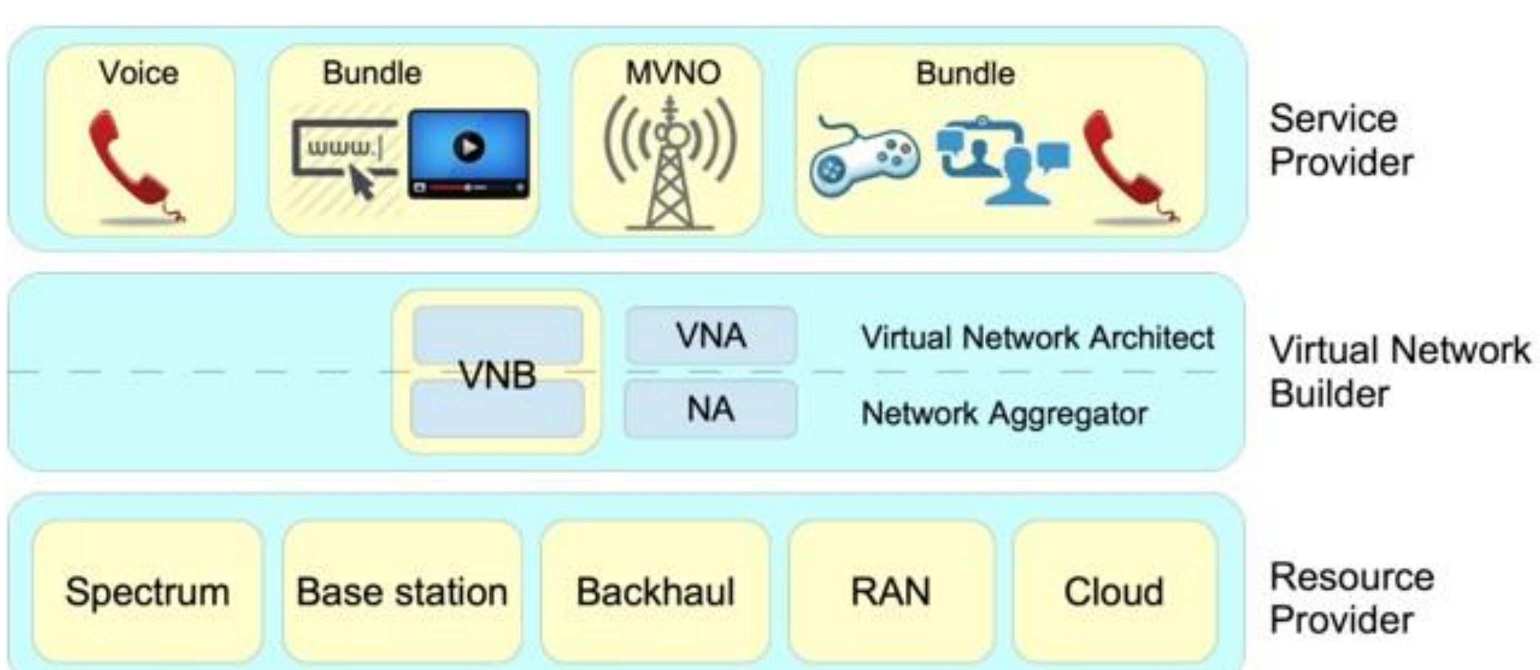

Fig. 1. Roles in the Networks without Borders paradigm

Service Provider (SP): Can be a traditional mobile virtual network operator (MVNO) that offers data, voice, and messaging services, a specialized MVNO that offers data services for specific applications (e.g. support for IoT devices), or any other over-the-top services.

Virtual Network Builder (VNB): Consists of a Virtual Network Architect. It composes and aggregates the virtual resources from the resource providers (RPs) to build virtual networks for the SPs.

Resource Provider (RP): The owner of a set of resources that can be offered as virtual resources in a set of pools, according to contracts established with VNBs or NAs, for example. In general, an RP will define how to slice and share its resources as virtual ones.

IV. Results

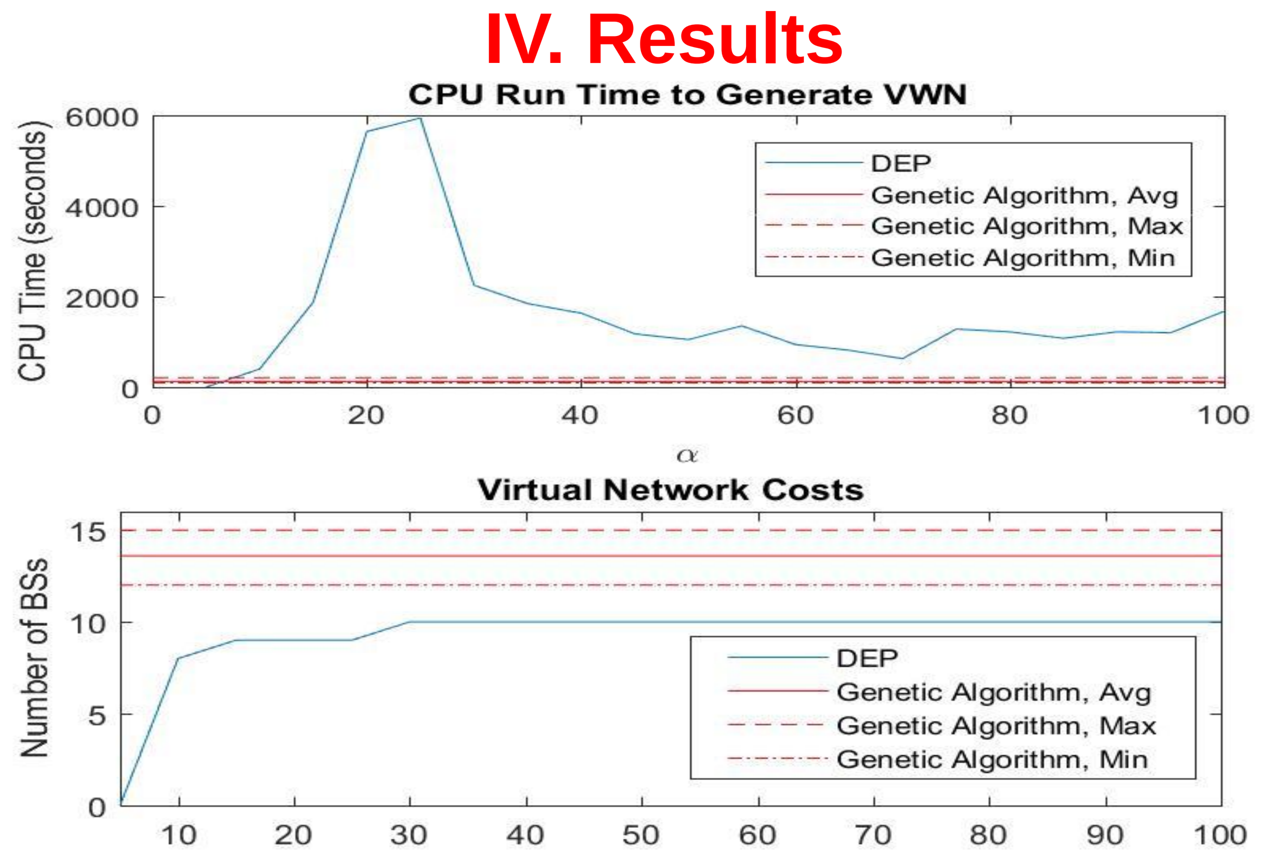

Fig. 4. CPU Runtime and BS Costs of sDEP, GA Approaches

- GA runs in appx. 2% ($\alpha = \{20, 25\}$) to 13% ($\alpha \geq 30$) of the time
- GA incurs appx. 20% (2 BSs) additional cost compared to sDEP
- (Not shown) Due to increased selection, GA has improved demand satisfaction (>99.99%) compared to sDEP (99.0%)
- GA is more tractable; may incur less comparative cost with larger (higher resolution) data sets.

III. VWN Construction

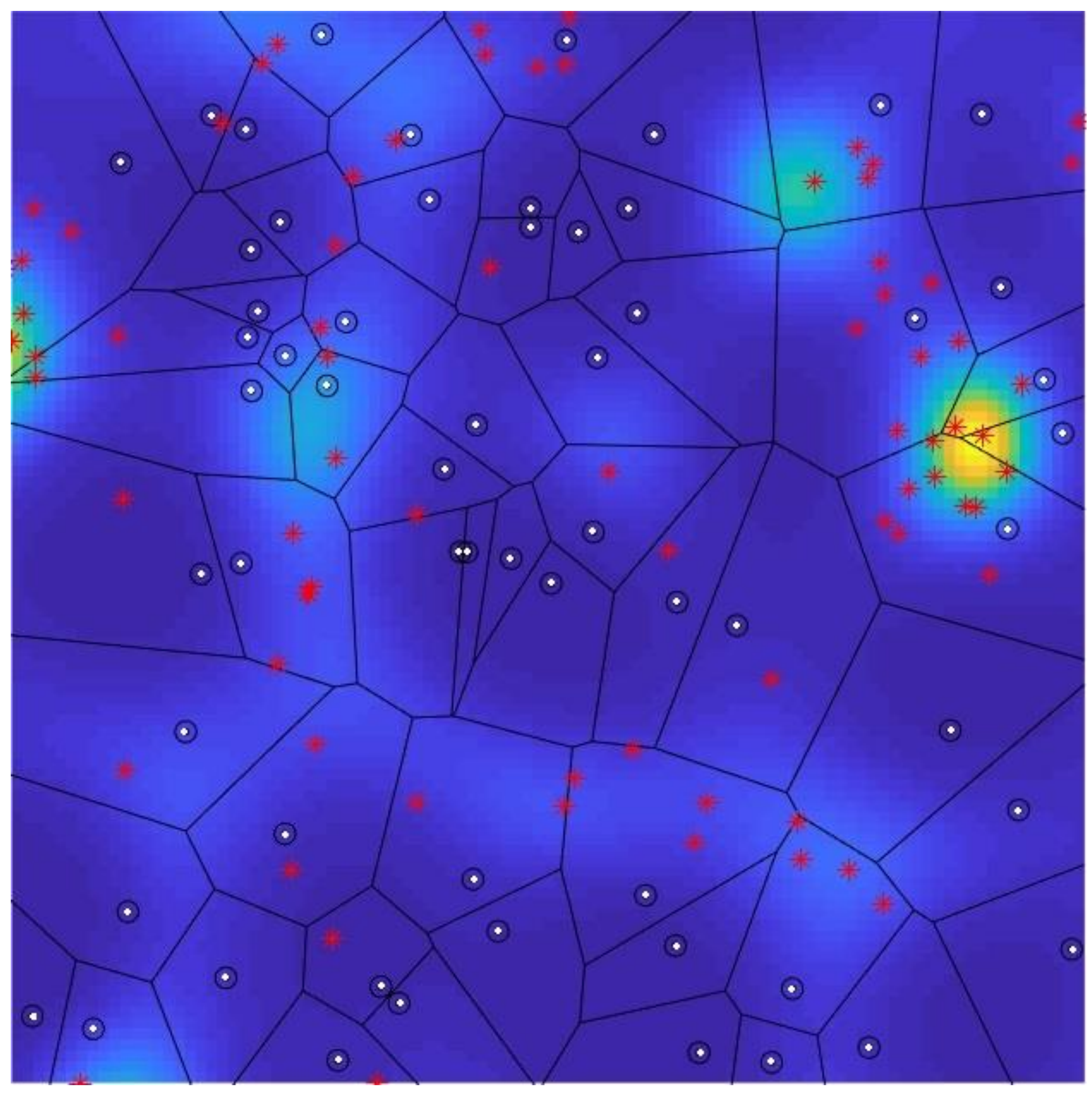

Fig. 2. Example area containing SP demand points (red) and field (background; SSLT) and available RP resources (points white, Voronoi tessellation black; PPP)

Consider a geographic area in which a VWN is to be constructed. A set of base stations (BSs) are available to be rented from the local RPs, each with their own cost, capacity, and coverage range. A SP has a known continuous demand density field to satisfy, which at any given time is realizable to a set of demand points (DPs) according to the continuous field.

The VNB aims to find and select the base stations with minimal cost that, when allocated to the SP demand points, generates maximal demand satisfaction. This is modeled as a two-stage stochastic optimization model, with homogenous demand points in stochastic locations. This is not possible to solve directly, so we present two approaches to solve the model that could be run within the VNB.

Sampled Deterministic Equivalent Program (sDEP) Approach: We convert the stochastic optimization model into a deterministic equivalent program (DEP), which replaces the stochastic variables with deterministic ones. These are composed of a set containing all scenario realizations of the stochastic variables. We use a sampling approach to trim the set to a solvable, finite form for a linear solver.

Genetic Algorithm (GA) Approach: A major restriction of sDEP approach is its intractability. The GA approach attempts to find a tractable approximate solution to the base station selection stage.

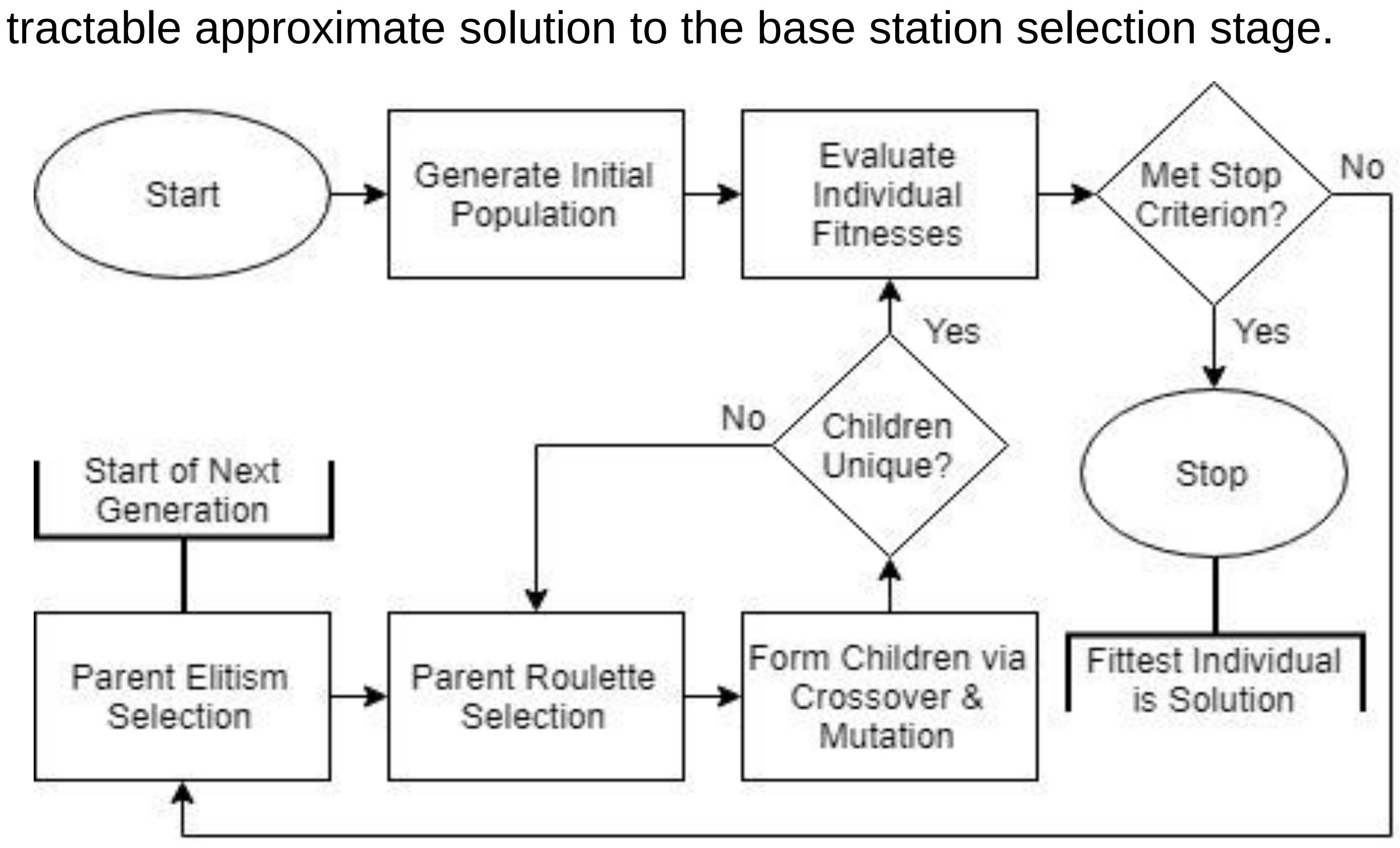

Fig. 3. Genetic Algorithm Flowchart