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Location Analytics and Prototype Design for Site Selection and Service Area Analysis

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ABSTRACT

Business expansion to a newmarketplace is data-driven process that requires spatial data analysis at every step. Location Analytics is taking a lead role in facilitating such location decisions. Expanding businesses are venturing into new markets with addedassurance of success.Business success vision is made clear by spatial data mining that reveal the hidden patterns in segmentation and buying behaviours of consumers in a specific service area.The analyst can now deploy methods to derive insights into market's size, market potential, demographics, buyers' responses, and trends to ensure success by selecting the right business location that matches the business success criterion.

Key Words: *Location analytics, Service area Analysis, Drive Time Analysis, spatial data mining*

I INTRODUCTION

When a business is wishing for new clients, its directors have to choose from one of the two options of getting new customer base within the prevailing market or develop and expand into new marketplaces. The second option is often more intimidating, because deciding which marketplaces to ventureis risky. Administrators of former generation based these decisions on personal experience andgut feeling because the expansion was generally within a small geographic area. Now we live in a global economy where we may need to expand to unknown geographies and the expansion decisions may now have a larger margin for error.

Sooner or later every company faces this significant query of where to go next. Smart companies are using location intelligence to compare and assessprobablemarketplaces. The principalbody of knowledge for discovering these patterns in location-based intelligence is embodied in a planning tool called Network Analyst. The type of analysis that is needed for such decision-making is 'coverage analysis'. In Network Analyst that is done with the service areasolver. This is where one might find whathouses are within five minutes of the business outlet, what market areas ourbusinesses cover where there might begaps consumer need analysis or whereto build the new store [1]. This is also needed for setting up territories for franchises, sales executives and other forms of business expansion networks. Once aservice area is created,we can use thatpolygon to identify how much land, how many people, the demographics in thatarea and other layers of data to do whatever type of analysis we want to do.

Here we need to understand an important concept with service area coverage as to how itdiffers from buffer area analysis in earlier GIS based analytics.If we do a one-kilometrebuffer around a potential site it assumes we can travel directly across whatever physical and geographic elements that are in that buffer. An acceptable result is computed by usingstraight buffers,if people can move in any direction, but the type ofanalysis we are doing is travel alongstreets, so we use theservice area instead of the buffer. If these are customers are on foot, we do a walking mode service area analysis instead and it will give a different result set. The polygons,created by surface interpolation thatthe service areas generate, is a bit ofan art and the network travel time analysis is the science part of this analysis [2].

When we create these areas for example it might be a 5-minute drivetime service area around a potential businesslocation, what is being analysed istravel along the streets so those arethe lines that are covered.The polygonsare estimations or trying to interpolate a surfacethat these lines cover these through streets. So it is the street travel we are doing and polygons are interpolated or approximated on top ofthem [3]. In ArcGIS pro and ArcMap this is calledthe service area solver. In ArcGIS online it's calledcreate drive time areas.Even if we are doingwalking time analysis it is still called the drivetime area with walking as the mode of travel. Service area coverage and site selection are always conducted together. The site selection toolkit in Network Analyst is theLocation Allocation Solver. The algorithms used in these computations are the smallest distance algorithm by Dijkstra, best route solver algorithm Route and the OD Cost matrix algorithm.

The idea here is,where do we want to build our business site in the marketplace depending on the demandthat's available.Where we think thecustomers might be located on this network. The network analysis is done by travelingalong streets so internally we foundstreet distances between the demandpoints and the proposed site and pickedthe best locations out of the candidatesto service the most demand in this area. Location is tremendously importantand location allocation algorithms helps us in picking locations along the network to decide where to build the business outlet [2].

II RELATED WORK

One common use case of the service area solver is to examine the response time of the fire departments how long does it take to arrive at an incident after a fire department receives a call for help. The goal is to visualize the three minutes response time area within each of thefire station. The existing routing algorithms were modified using python scripts because fire service vehicle travels through the network differently than a regular vehicle [4]. They are not required to observe the barriers and turn restrictions and may even drive on one-way routes or on the wrong side of the road. For this the authors reprogrammed and created lists for Fire service vehicle travel mode.

A similar modified version of location allocation analysis was researched by choosing the nearest police vehicle to reach up to a crime spot. The location allocation solver was used to identify the police vehicle facilities from a given set of nearby locations from a given crime incident [5]. The authors experimented on several parameters thatcan help solve needs like arrivetimes and time windows and service times. They also computed time impedance functionality using the find nearest tool [6].

The application domain of this next study was a mining company with a data analysis objective of contracting with a third party company to haul awayand process the waste products from thework sites. The study computed coverage analysis and service area where the company wanted to know anarea around a facility that a dumping vehicle can getto in a certain amount of time [7]. There was a dual task of fleet optimization for optimizing the fleet of vehicles with two connecting sets of locations with the OD costmatrix solver and closest facility.The authors researched how network analyst fits into computing solution for this kind of situation [8].

Several authors researched the application of location allocation algorithms for routing the customers inside of a building with the study objective of identifying the best places to put all the Automated external defibrillators devices. AEDs are movable, medical devices intended to medically assist individuals suffering from unexpected cardiac arrest. This is a therapeutic disorder in which the heart halts pumping blood unpredictably and without warning [9].The location decision was made by calculating general flow of people, depending on where there's theheaviest population in the building. Themost appropriate places were computed so thateverybody can get to a defibrillatorwithin a minute time.

In ArcGIS Pro the evaluate site workflow is available from the business analyst menu. This allows the user to conveniently locate a potential site build a trade area and discover facts. This is one of the fundamental parts of real estate analysis [10]. The authors selected a three,six- and nine-minute walk time to see what's immediately around the real estate residential site.

III METHODOLOGY: SOLVING THE LOCATION ALLOCATION PROBLEM

Location is frequentlyaccepted as the most significantaspectto ensure success of business expansion to a new site. Selection of the right site is important for solving the following problems:

- ✓ Reduce Cost Impedance or Distance Impedance
- ✓ Achieve maximum coverage for the upcoming business site
- ✓ Ensure connect with maximum consumer capacity and attendance
- ✓ Achieve marketplacesegment goal

Specifiedservicespoints that are responsible as provider nodes and demand points playing the role of consumer nodes, the objective of location-allocation is to compute location for new sites for efficient supply of services to the demand points.Thus, it is a two ponged algorithm of locating a set of service nodes and then allocating them to the other set of demand nodes [11].

The Location Allocation Analysis Layer provisions the inputs, constraints, and output to generate the solution space.

Generating a Location Allocation Analysis Layer

Using Arc GIS Network Analyst we generate the initial solver layer

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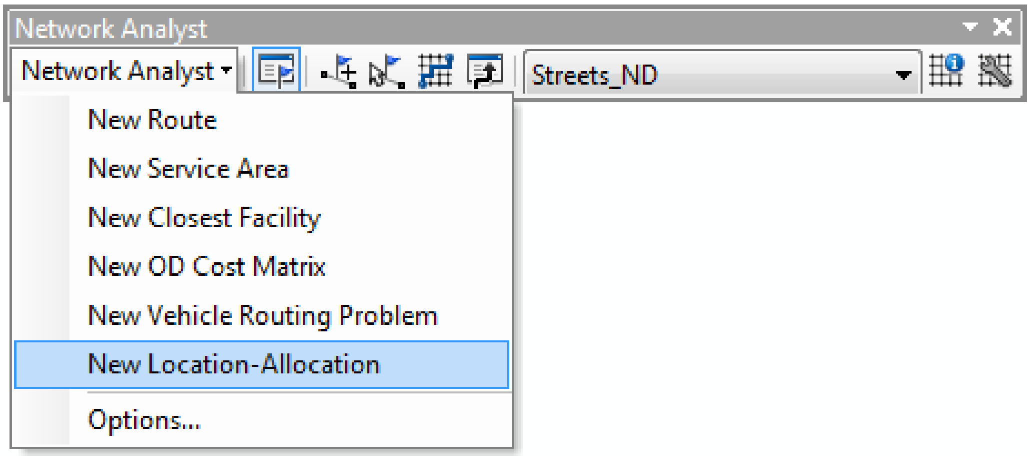

Fig. 1.Instantiate new object for Location Allocation Solution Layer

There are six network analysis classes through which we can set the class properties to compute the optimal selection of a new candidate site.

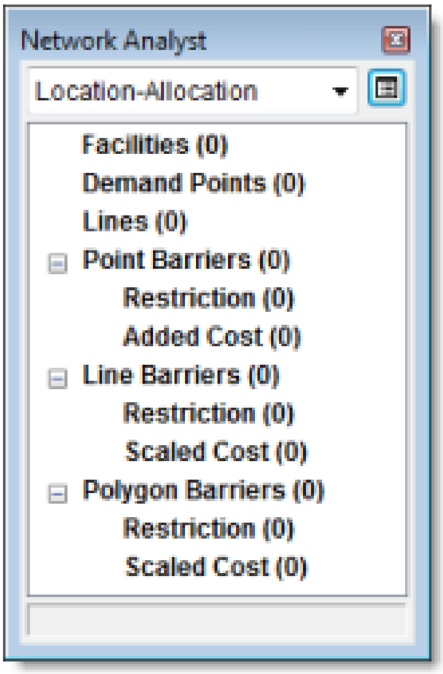

Fig. 2. Set Class Properties

- Prepare demand nodes and service nodes datasets and load them to the network analyst solver layer.
- Load the road network layer on which the computations are to be carried out.

Pseudocode

The Pseudocode for computing the solver layer is summarized below:

1. Compute Critical success factors and define success parameters
2. Allocate Service Demand to the Central Facility.

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3. Compute nodes for least cumulative travel cost
4. Design p-median solution
5. Identify best sites by computing minimum weighted impedance nodes in service nodes and allocate them to demand nodes.
6. Set objective function
7. Compute Local Optima
8. Compute Global optima
9. Seed Initial Solution
10. Apply Global Regional Interchange Algorithm to progress in the solution space
11. Remove a global node from the solution space and replace it with the node to maximise reduction in total weight
12. Repeat step 11 till no further reduction in weighed distance is possible
13. Repeat step 11 and 12 for Local nodes till no further reduction in weighted distance is possible.
14. Optimise to expand consumer footfall
15. Optimise to achieve the desired market share.
16. Interpret Solution space and provide solution as a ranked list of candidate sites.
17. End of Location Allocation Analysis

IVMODELLING THE SOLUTION AND TASK ABSTRACTION

Objective: Business expansion to new locations

Methods and Material:

- Identify success variables by conducting analysis of existing sites
- Expand understanding of distinguishing characteristics for similar successful business locations
- Identifyappropriatemarketplaces
- Compute Suitability analysis for identified marketplaces
- Confirmcontenderlocations and examineappropriateness of specificlocations
- Compute Suitability analysis for contender locations
- Derive Inferences and insights and advice solution

V DATA DESCRIPTION

The datasets used in conducting the business expansion analysis experiments are:

- Base Map layer World Topographic and network dataset
- Facilities dataset for current locations
- Geo-enrichment Layer with population and demographic data
- Existing customer data and CRM dataset
- Competitors Data
- City Classification data

- Candidate Market Layer
- Candidate Sites layer
- Associated Facilities layer such as Gyms Layer, Theatre Layer
- Walkability Index Layer

VI VISUAL DESIGN AND DEVELOPMENT

In this prototype application for business expansion analysis, we initiate by analysing the existing customer base and existing stores. This helps us in understanding the success criterion better.

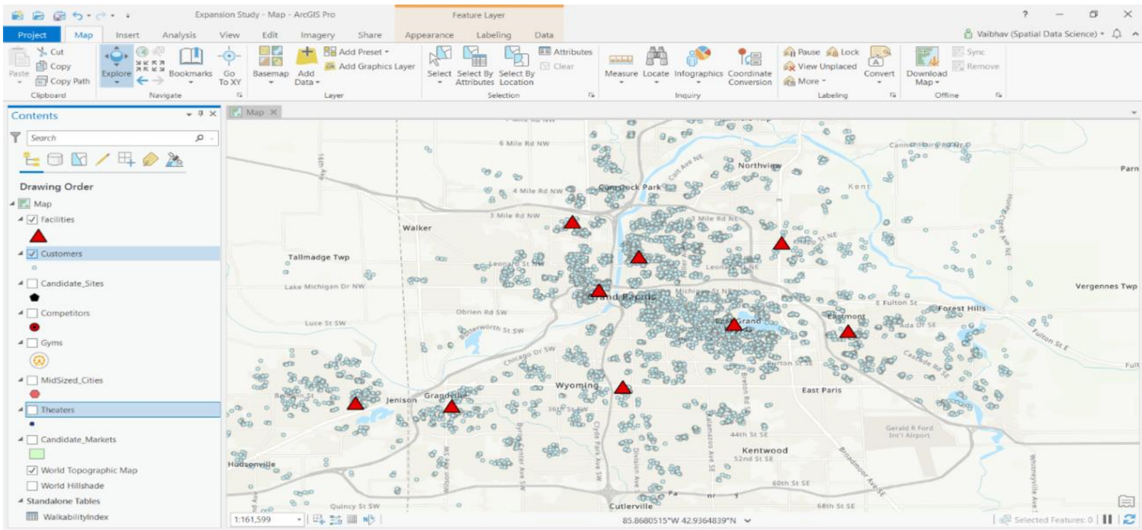

Fig. 3. Visualizing Current Business Locations before expansion

In this phase we are trying to understand the market characteristics and funnel it down to identification of submarkets. We geocode the existing stores and organise it as a feature layer [12].

We also create feature layers for associated facilities such as Gym or theatre etc.

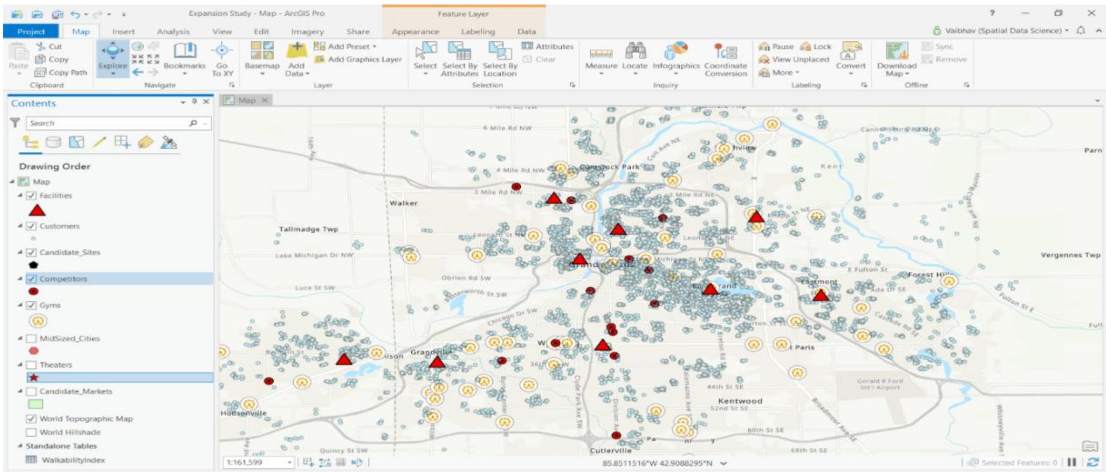

Fig. 4. Site analysis with additional facilities

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Next we need to analyse the competition so we would organise the competitor dataset and create a feature layer for competitor analysis

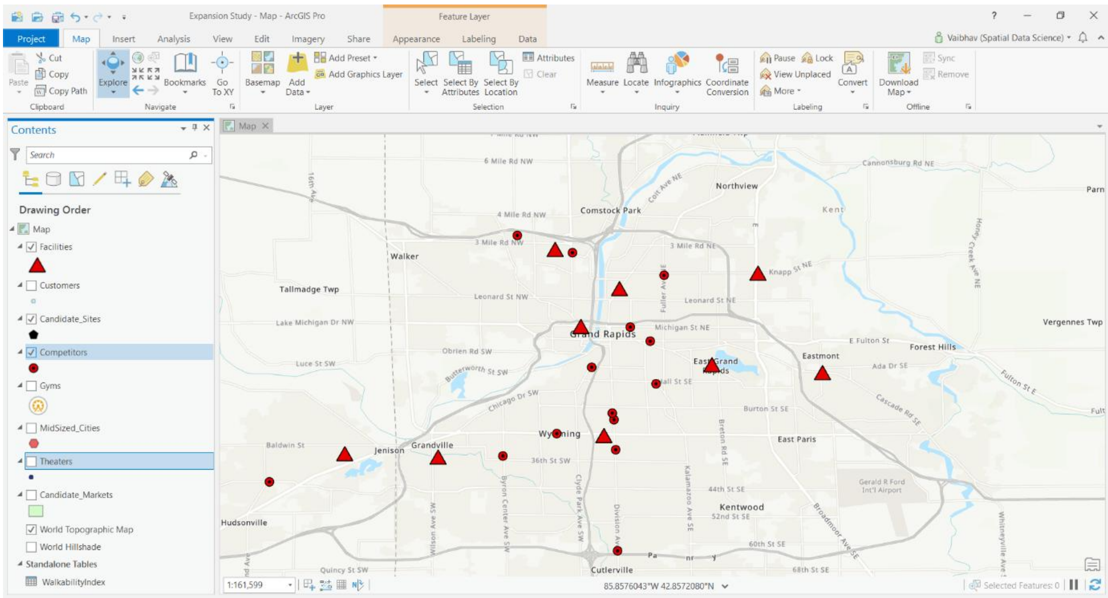

Fig. 5. Visual Analysis of competitor dataset

Trade area Analysis is based on customer analysis and is to be conducted for the existing business sites as well as competitors. Through trade area analysis we would like to compute the customer base in the vicinity of existing stores as well as the candidate sites. We also analyse the sales performance of the existing trade areas [13].

From the geo enrichment layer, we colour code the high population density areas. We may not be essentially looking for the very high population density areas as they are generally flooded with competition. What we are looking at is a strong customer base in combination with latent customer demand. Several other attributes are analysed to arrive at the suitable candidate site [14]. The success stories of the successful stores are to be used as attribute variables of the suitability analysis. Each variable is analysed as a feature layer with the suitability analysis layer.

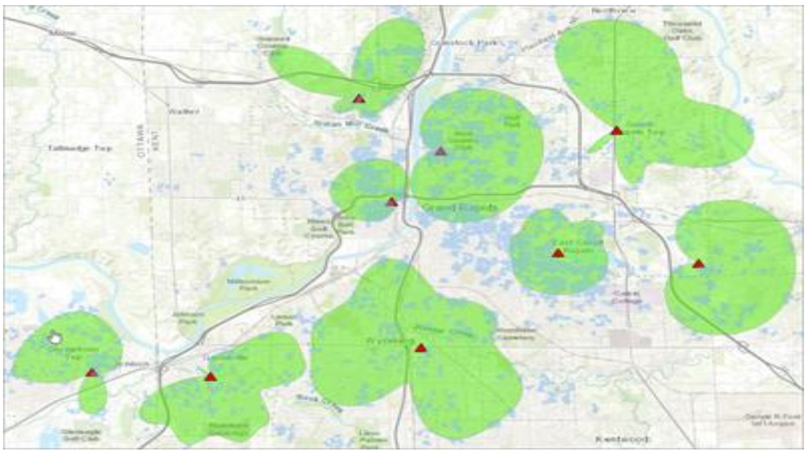

Fig. 6. Trade area Analysis

We compute weights and scores for the candidate sites and do a similar analysis for competitor sites. All attributes start with the same weight and then we may increase or decrease the importance of the attribute by adjusting the weights. For example,a greaternumber of competitors in a location, can be assigned a negative weight and this would reduce the attractiveness of the site. This also permits multidimensional analysis where multiple factors and attributes can participate in the analysis. The suitability analysis layer computes the suitability score using weights and reassign symbols and colours based on suitability score. In this way we analyse the neighbourhoods to analyse market suitability and site suitability. Finally, we can rank these markets and sites according to their attractiveness and match it with the available commercial sites on selected locations. The summary reports contain additional details and business profiles related to the proposed site.

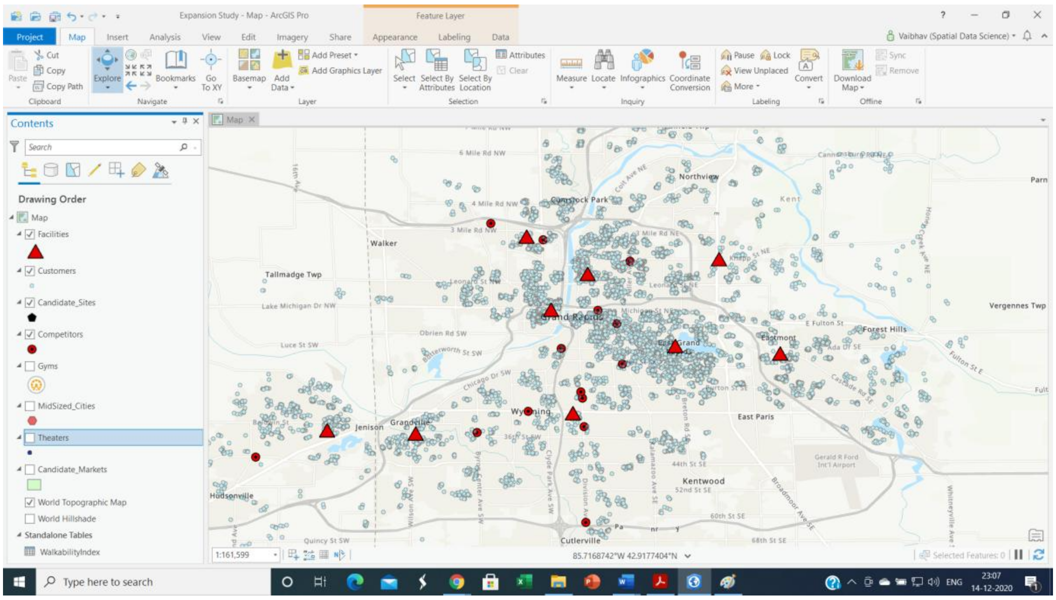

Fig.7. Customer Competitor and Candidate Sites for finalising site suitability.

VII CONCLUSION

Business expansion is a need of every company and identification of right location is highly important. Businesses now have the right tools available and should not waste resources and time in experimenting with the wrong locations. These unplanned expansion experiments are costly in terms of wasted resources, wasted time and missing the opportunities of right locations. The earlier methods of planning busines expansion, based on personal assumptions, are fast getting replaced by the data centric location analytics. Now is the era of location intelligence to reinforcesureness in success of expansion plans by deriving insights from data and analysingseveralinformationresources. The intelligent way of expanding business a new site is to identify locations that personify that specific feature combination for success using location analytics.

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