A Future Scenarios-Based Computational Framework for Campus Planning

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Future forecasting methodologies and computational applications are applied for developing an interactive design framework in campus planning process. The proposed computational design framework programs various design rules intended for producing buildings with optimized capabilities to adapt to their future settings and meet the functional requirements based upon future scenarios. The implementation of the computational framework for the future scenarios based campus planning is introduced.

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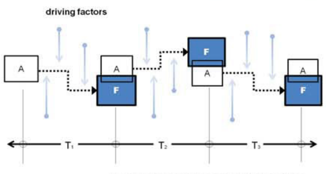
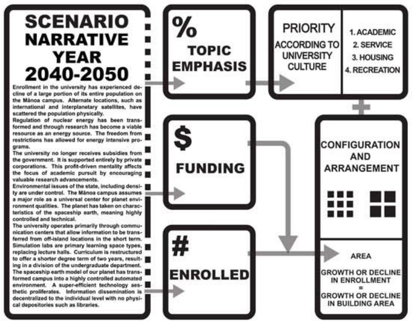
INTRODUCTION

The planning of physical facilities and supporting infrastructures is based upon a very definite commitment, from various stakeholders, to a future which we hope will arrive. However, there is no certainty as to what it will actually be. Because of the time and resources involved in this endeavour, it requires a better method for envisioning and programming the most probable future setting for which to design our buildings. It has been a challenge for current decision makers in higher education to forecast various future alternatives for the institution in order to guide them to a preferred scenario that meets the needs of tomorrow's students (Dator, 2006). Collective statements from various stakeholders' future projections require interpretation so that an ontological decomposition of the statements will provide structural ordinance for the categorization of potential futures (Gruber, 1993). Four generic alternative futures employed for forecasting the future scenarios of institutions or community are 1) Continued Growth, 2) Collapse, 3) Disciplined, and 4) Transformational. The four alternative futures are to be used as axiomatic measures to forecast a preferred future for a given campus. Each alternative future scenario has its own characteristics responding to various driving forces that propel the evolution of the campus (Dator, 2009). **The information characterized by the driving forces in a future scenario becomes the source for quantifying architectural program requirements in the planning of a future campus.** It guides the application of design rules for the development of a future campus with the help of a three-dimensional modelling application, Rhinoceros 3D, and its plug-ins. The proposed future scenarios based computational framework is employed to provide the convenience of experiencing and envisioning alternative futures. This computational framework is propelled by the dynamic comparison between 1) Future scenarios (F), and 2) Actual present result (A) in a given time frame (Ti).



F: Future, **A**: Actual present result, **T**: Time frame


SCENARIO NARRATIVE YEAR 2040-2050

Enrollment in the university has experienced decline of a large portion of its entire population on the Mānoa campus. Alternate locations, such as international and interplanetary satellites, have scattered the population physically.
Regulation of nuclear energy has been transformed and through research has become a viable resource as an energy source. The freedom from restrictions has allowed for energy intensive programs.
The university no longer receives subsidies from the government. It is supported entirely by private corporations. This profit-driven mentality affects the focus of academic pursuit by encouraging valuable research advancements.
Environmental issues of the state, including density are under control. The Mānoa campus assumes a major role as a universal center for planet environment qualities. The planet has taken on characteristics of the spaceship earth, meaning highly controlled and technical.
The university operates primarily through communication centers that allow information to be transferred from off-island locations in the short term. Simulation labs are primary learning space types, replacing lecture halls. Curriculum is restructured to offer a shorter degree term of two years, resulting in a division of the undergraduate department.
The spaceship earth model of our planet has transformed campus into a highly controlled automated environment. A super-efficient technology aesthetic proliferates. Information dissemination is decentralized to the individual level with no physical depositories such as libraries.

% TOPIC EMPHASIS

PRIORITY ACCORDING TO UNIVERSITY CULTURE

1. ACADEMIC
2. SERVICE
3. HOUSING
4. RECREATION

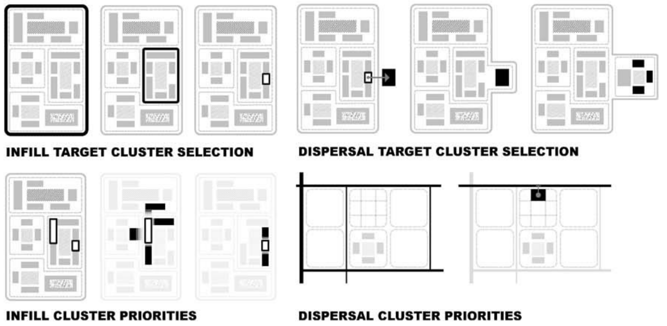
$ FUNDING

CONFIGURATION AND ARRANGEMENT

ENROLLED

AREA

GROWTH OR DECLINE IN ENROLLMENT = GROWTH OR DECLINE IN BUILDING AREA


INFILL TARGET CLUSTER SELECTION

DISPERSAL TARGET CLUSTER SELECTION

INFILL CLUSTER PRIORITIES

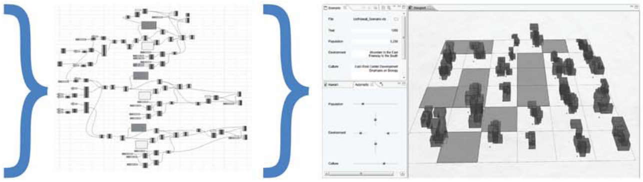
DISPERSAL CLUSTER PRIORITIES

SCENARIO BASED PROGRAMMING

Any future scenarios for a campus are the results of a number of driving forces acting as space planning determinants. The driving forces that propel a campus toward its future are identified as governance, environment, energy, economy, population, technology and culture. Future scenarios for the campus can be constructed by the collective result of these driving forces. In action each driving force possesses a cause and effect relationship to the physical form of the campus. With a future scenario provided in narrative format, simplified values for population, economy and culture are filtered from the seven driving forces. These extracted values become the source for projecting the enrolment at the physical campus, financial resources allocated to the university facilities department and areas of university emphasis. The quantifiable values (i.e. enrolment and funds) are translated into the floor area of potential buildings for campus development. **The university emphasis is used to determine the function of the buildings to be developed. The major functions of the campus have been categorized as 1) academic, 2) service, 3) housing, 4) recreation.** The functions of the campus are prioritized by the university emphasises emphases extracted from the scenarios. Financial resources and the cost per square foot also influence the size of buildable areas. Buildable areas are allocated to each category of building function and divided into an appropriate number of buildings. The number of buildings is determined using an acceptable range of size depending on building function.

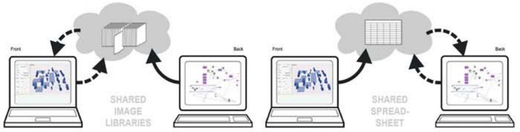
DESIGN RULES

Various design rules are investigated by observing the evolution of prototypical university campuses under the influence of driving forces. The driving forces for the various campus changes were identified by analysing the relationship between the physical and operational elements of the campus. The driving forces, along with other dimensions of higher education and universities were considered. These dimensions include: societal assumptions, mission, participants, pedagogy and available resources including physical structures. The prototypical campuses are Cornell University, Harvard University, Stanford University and University of Virginia. The design rules are applied and confirmed with the evolution of seven additional campus designs. After the program has been planned, the possible financial resources and space requirements for various subjects (i.e. academic, service, housing and recreational unit) are determined for projected future campus. Furthermore, the development pattern of the future campus, such as infill and dispersal, is defined for applying design rules. The design rules allow a user to decide 1) target placeholder for developing future campus buildings, 2) configuration of the buildings with parametric changes, and 3) the arrangements of the buildings to accept a range of potential future scenarios. **The design rules direct the decision making process of the future campuses, considering districts, paths, edges, nodes, and landmarks of the campus (Lynch, 1960).** In this paper, districts are understood as a group of building clusters that have some common characteristics. Paths are regarded as circulation or streets that have different weight values which influence the selection of a target placeholder and configuration of a building. Edges are the boundary conditions between two clusters. Edges delineate the configuration and arrangement of buildings. Nodes are the strategic foci in a campus where common characteristics are concentrated forming the quads or malls of the campus. Landmarks are key buildings to attract the target placeholder, influence the configuration of buildings, and clues for their arrangement. The distribution of key buildings (landmark or seed buildings) is observed in the development of various campus designs including the four prototypical universities. It has been observed to follow either an infill or dispersal development pattern.



THE FLUCTUATING DISTRIBUTION PATTERN IS RELATED TO THE CHANGES OF CAMPUS POPULATION AS SHOWN

The development pattern acts opposite to the increase and decrease of enrolment. The dispersal of key buildings happens when enrolment experiences a decreased rate, rather than both of them decreasing simultaneously. An infill pattern of development comes with an increase in enrolment. The infill and dispersal patterns are decided by the forecasted population filtered from future scenarios, to guide the application of other design rules.

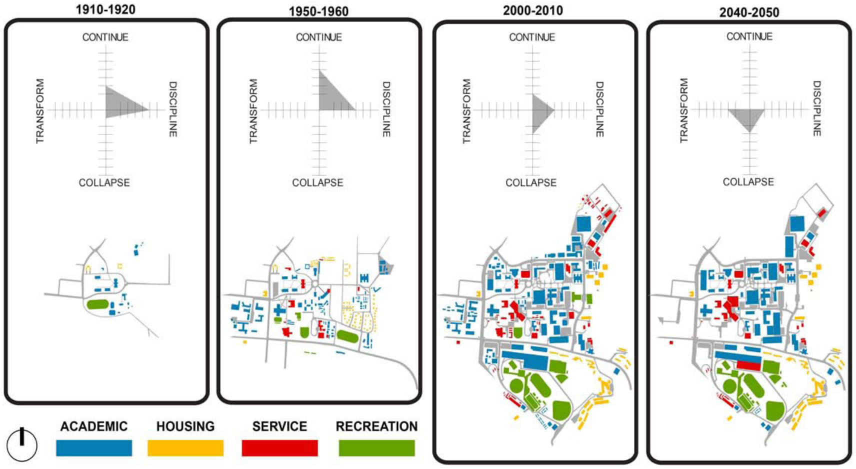


PROJECTION

After identifying the recurrent patterns and design rules from the campus design analysis (Alexander et al., 1977; Beirao & Duarte, 2005), the patterns are translated into a computational framework (Gamma et al., 1995) that uses the quantified information from future scenarios as input for projecting future alternatives. The projections are mainly performed within Rhinoceros 3D, a three-dimensional modelling application, and its scripting environment called Grasshopper. Genetic Algorithms are employed for guiding the evolution of the alternative future campus designs based upon a fitness function with various weighted values assigned to the parameters of the patterns and the rules as shown in Figure 8 (Park, 2008).

DISTRIBUTION

The proposed future scenarios-based computational framework includes real-time web-based distribution with the integration of 1) 3D back end, 2) cloud based server, and 3) web-based front end as below. The current implementa-tion of the distribution has been made with Rhinoceros 3D & Grasshopper, Google Spreadsheet, and Processing, an open source programming language and integrated development environment (IDE).



ACADEMIC 🟦 **HOUSING** 🟨 **SERVICE** 🟥 **RECREATION** 🟩

EVOLUTION OF UHM CAMPUS (1910 – 2050)

Using the proposed future scenarios based computational framework, a series of campus developments from 1910 to 2050 is generated per ten year time frame for the University of Hawaii at Manoa. The driving forces for each timeframe are expressed in terms of the four alternative campus futures (i.e. Continued Growth, Collapse, Disciplined, and Transformational). The sum of the forces indicates the trend for the growth pattern of that time period. During the period from the beginning of the University of Hawaii until the year 1920, the campus saw a diminished increase of student enrolment and trivial economic control. These factors generated a trend of disciplined growth. This trend shifted in the 1950s toward continued growth, when enrolment began to increase and statehood allowed for more stable and influential economic influences. This trend begins to reverse in 2010, towards collapse, as indicated by a slight decline in enrolment. The forecasted future fifty years from now anticipates a transformational and collapse trend, due to increasingly centralized govern-ment and dominant control of the economy.

DISCUSSION

The future scenarios are described mainly for the purpose of demonstrating the formal development of campus and are not necessarily an accurate repre-sentation of the result of the driving forces. Forecasted futures are different from actual present results. The comparison between them is a critical factor for establishing the next scenario. This judgement is made by the stakehold-ers of campus development, which may be open to interpretation. In return, it encourages more stakeholder participation and input for defining the parameters and constraints of future campus development. The scope of our proposed framework is still limited by the set of available patterns or design rules which have been extracted from the case studies of 12 universities in the US. The design of the proposed framework considers the scalability of patterns or design rules as observed in other case studies. Its scalability is based upon the extensive usage of the driving forces in other cases. The enhancement of the framework is being made on its front end with improving and updating its image library to more compatible abstract programming interface (API) with HTML5, SVG, or WebGL.

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