Academy of Architecture for Health
On-line Professional Development

Generative Design for Healthcare Planning

Masters Studio Series

07, November, 2017

2:00 pm – 3:00 pm ET

1:00 pm – 2:00 pm CT

12:00 am – 1:00 pm MT

11:00 am – 12:00 pm PT

Presenters
Diana Davis, AIA, LEED AP
Perkins + Will

John Haymaker, Ph.D., AIA, LEED AP
Perkins + Will

Moderator
Rita Ho, LEED AP

AIA Knowledge Community
Academy of Architecture for Health

AIA

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Masters Studio Series

The Academy's multi-channel on-line approach provides emerging professionals, journeymen, and master professionals with convenient and economical opportunities to develop their chosen area of interest.

Masters Studio Series sessions are tailored to provide healthcare design professionals with sufficient exposure to jump-start interest in wanting to learn more.

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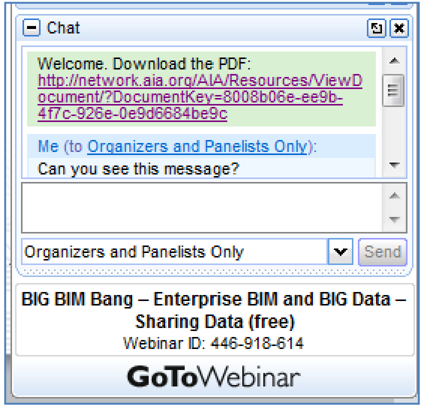
Follow the link provided:

- **in the Chat box** at the conclusion of the live presentation;
- **in the follow-up email** you (*or the person who registered your site*) will receive one hour after the webinar.

Questions?

Submit a question to the moderator via the chat box.



Content-related questions will be answered during the Q&A portion at the end as time allows.

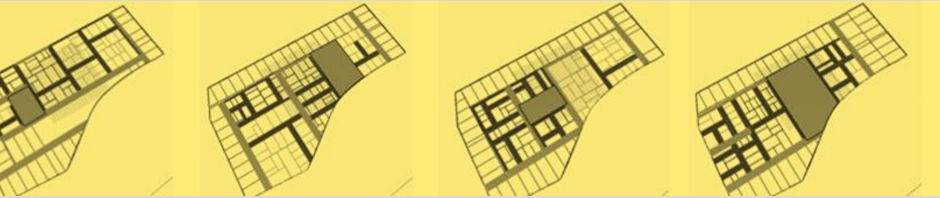
Tech support questions will be answered by AIA staff promptly.

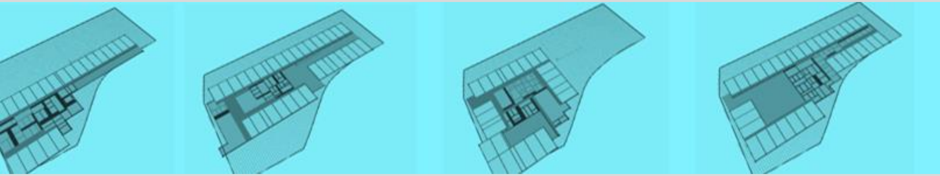
Computational Design for Healthcare Planning

Presenters

Diana Davis, AIA, LEED AP
Managing Director
Perkins + Will

John Haymaker, Ph.D., AIA, LEED AP
Director of Research
Perkins + Will





COMPUTATIONAL DESIGN

FOR HEALTHCARE PLANNING

AIA AAH WEBINAR SERIES / NOVEMBER 7, 2017

PROJECT COLLABORATORS

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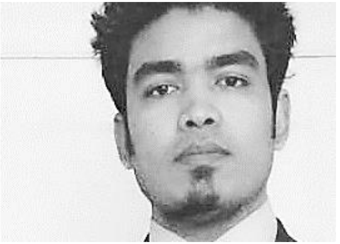
Healthcare Planner/Principal
Perkins+Will



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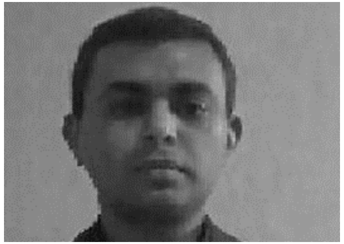

NIRVIK SAHA
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ANTHONY HAUCK
Director of Product Strategy
Autodesk

AGENDA / LEARNING OBJECTIVES

Fundamentals of Computational Design

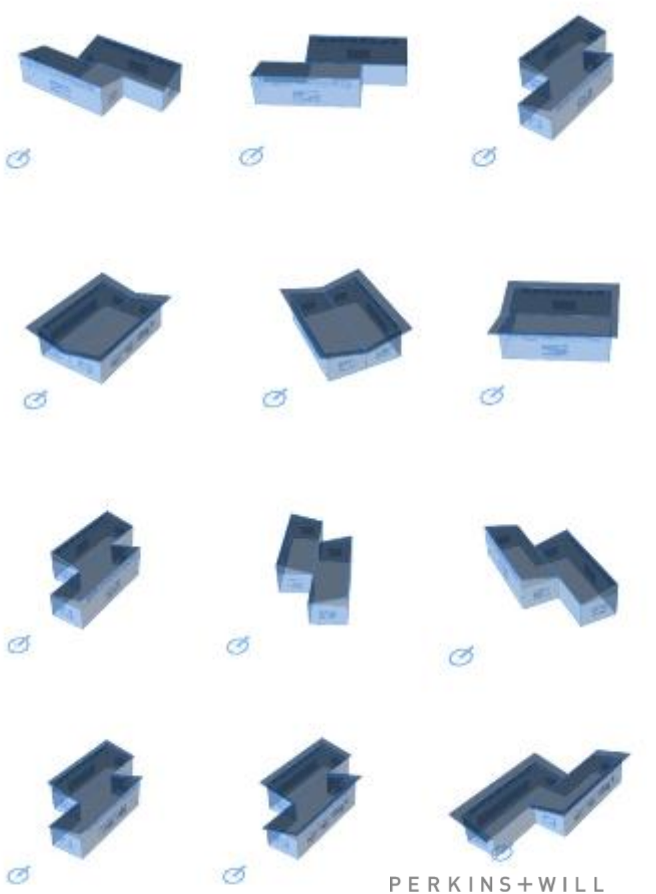
- *Understand the basic concepts and principals of Computational design and performance analysis*

Computational Design Applications

- *Discover the ways computational design can impact the future of design and planning*

Applied Research

- *Discuss ways to modify the programming and planning process to yield faster and more inclusive results*
- *Identify research informing the use of new digital tools and technologies as they relate to healthcare design and planning*



PERKINS+WILL

FUNDAMENTALS OF COMPUTATIONAL DESIGN

“Through the interplay of complex information with graphical representation and programming, new and fascinating visual worlds are emerging where the coincidental is shaped to help correlations become visible.” - Hartmut Bohnacker

PERKINS+WILL

COMPUTATIONAL DESIGN IS…

a paradigm shift

PREVIOUS PARADIGM

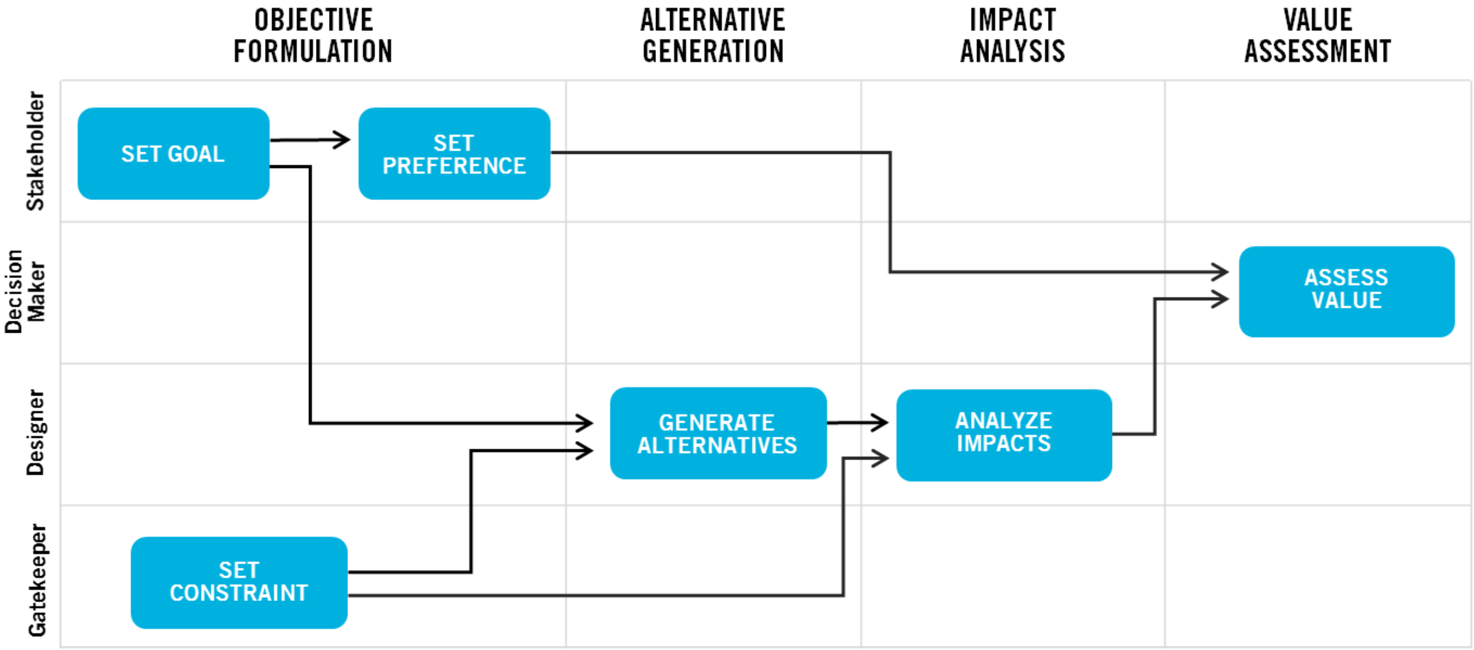
Designers must adjust their process to the tools developed for them by programmers

NEW PARADIGM

Designers use fabricated digital tools to become the programmers of their own individualized toolboxes

COMPUTATIONAL DESIGN IS…

Stakeholder Engagement, Computational Design, Impact and Value Analysis



SOURCE: Haymaker, et al (2017)

PERKINS+WILL

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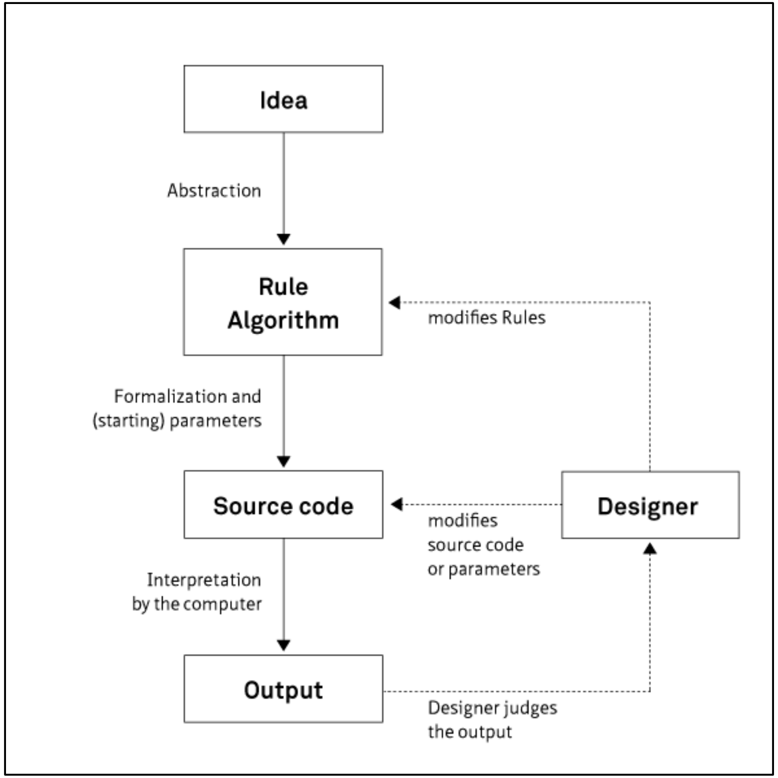
COMPUTATIONAL DESIGN IS…

Informed design exploration through the integration of simulation, analysis, and optimization.

Usually comprised of

- A design schema
- A means of creating variations
- A means of selecting desirable outcomes



SOURCE: Bohnacker, et al (2012)

PERKINS+WILL

COMPUTATIONAL DESIGN IS…

Comprised of a **feedback loop**.

Feedback models:

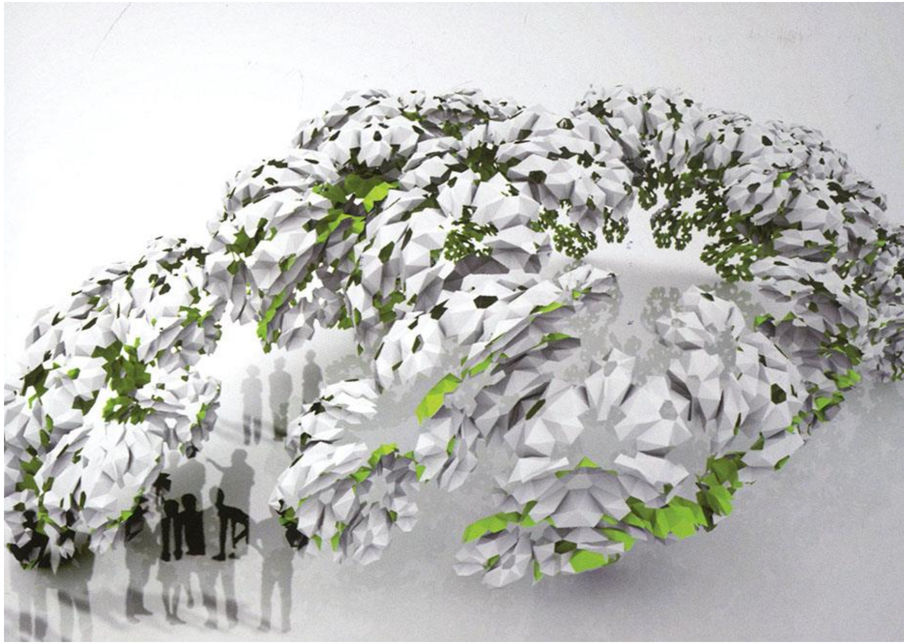
- Use the model’s own output for input
- Incorporate routines for design evaluation

Cyberflowers, by Roman Verostko (2009)
from Bohnacker, et al

COMPUTATIONAL DESIGN IS…

repetition

Repetition allows the computer to work on a problem until it has solved it, using the manipulation of objects



THEVERYMANY, by Mark Fornes (2007) from Bohnacker, et al

COMPUTATIONAL DESIGN IS…

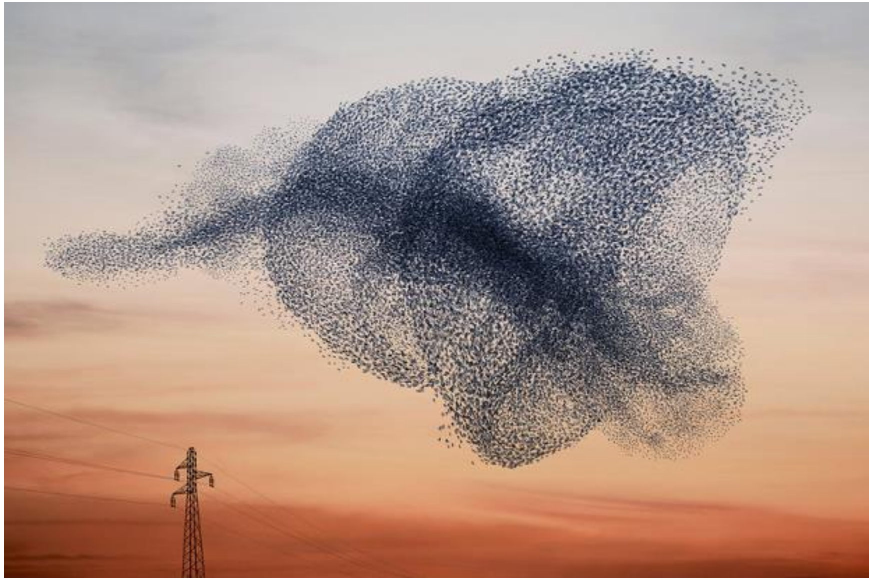
emergent

Process are **emergent** when their results are not pre-determined.

The interaction of the elements leads to more than is obvious from their individual properties

OR

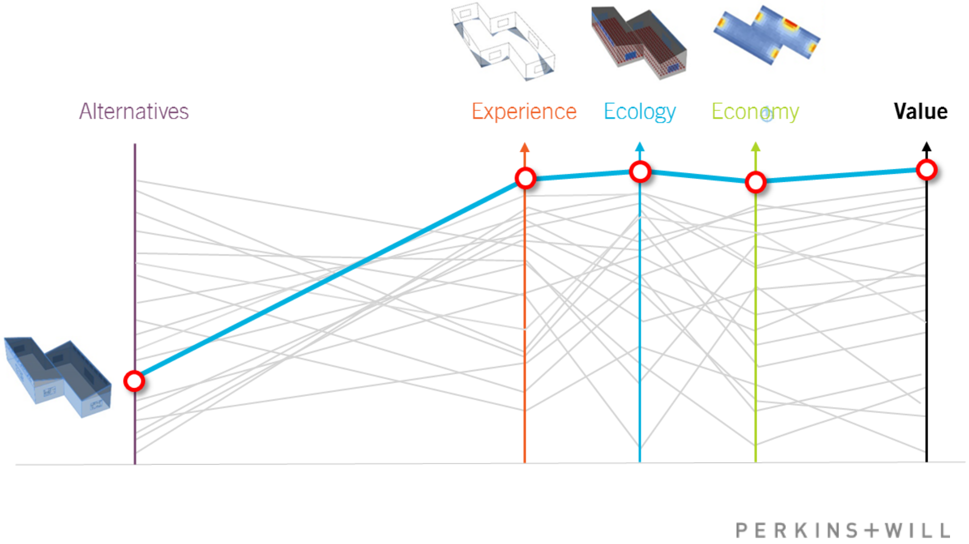
Simple rules result in highly complex, unpredictable behavior



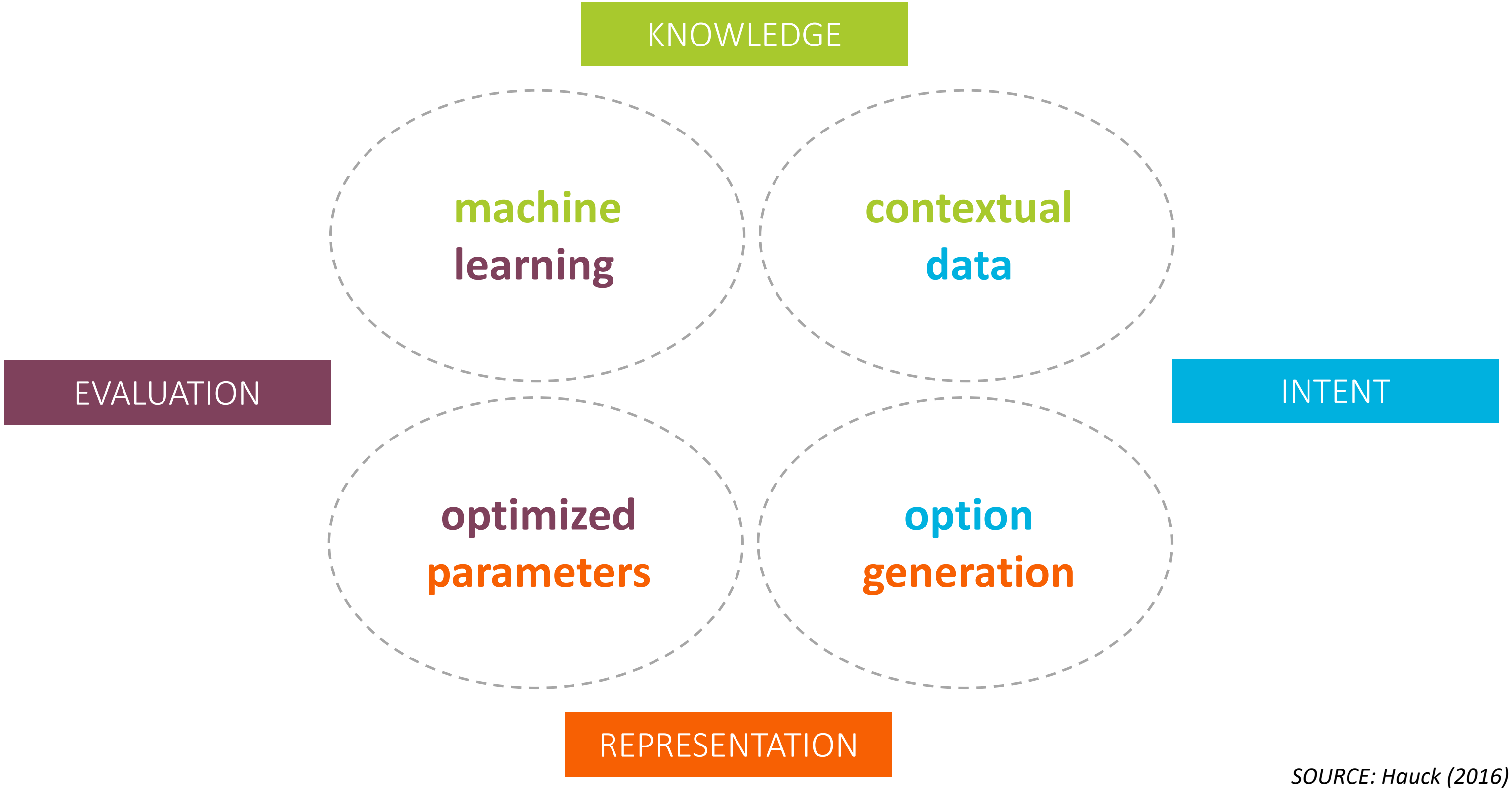
COMPUTATIONAL DESIGN CAN BE…

performance-driven

Processes are **performance-driven** when their results are seeking to maximize value



COMPUTATIONAL DESIGN IS…



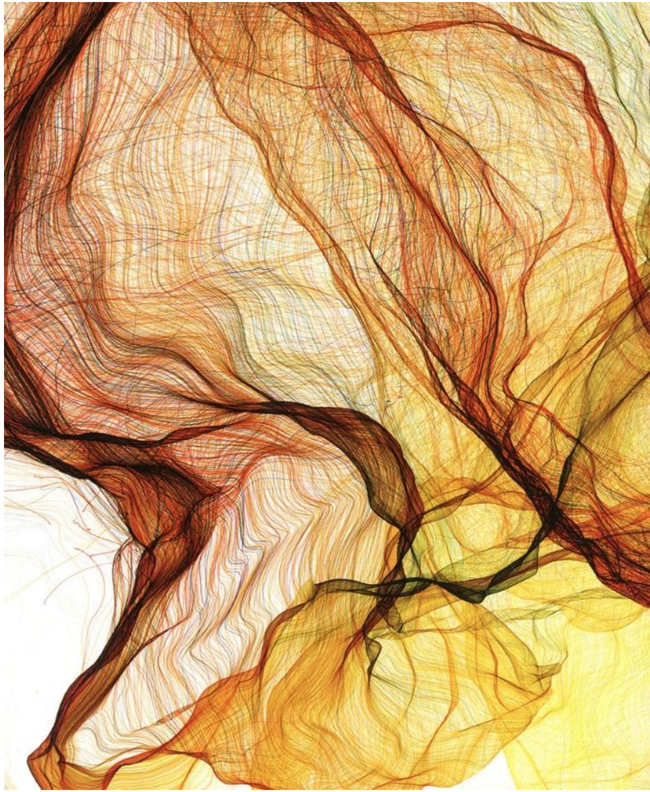
SOURCE: Hauck (2016)

COMPUTATIONAL DESIGN IS…

new possibilities

Some **building blocks** of Computational design thinking:

- Grids
- Agents
- Attractors
- Tree Diagrams



Red Ambush, by Enzo Henze (2008) from Bohnacker, et al

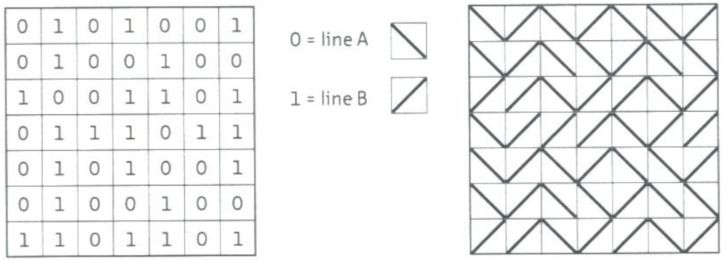
EXAMPLE: USING GRIDS

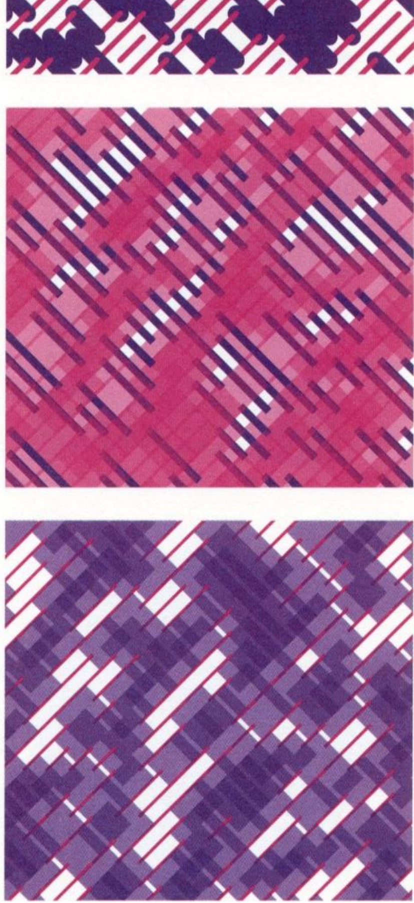
Goal - create a random pattern of diagonal lines

Method:

1. Randomly place “line A” or “line B” on a grid

2 d “B”





SOURCE: Bohnacker, et al (2012)

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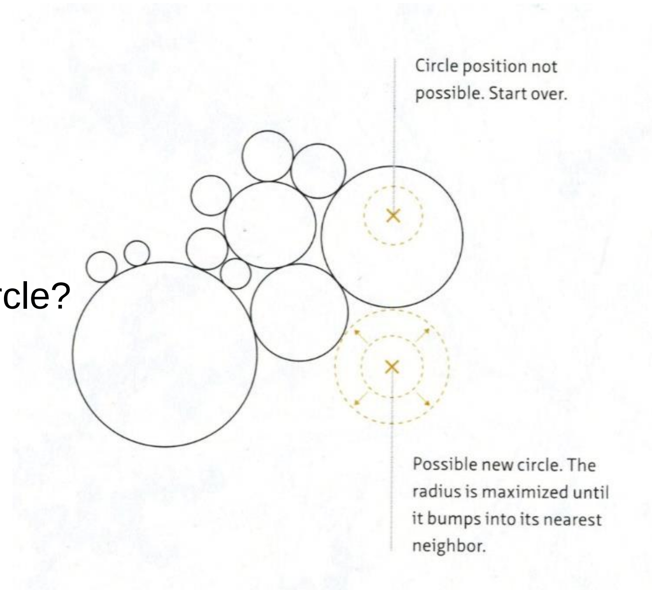
EXAMPLE: USING AGENTS

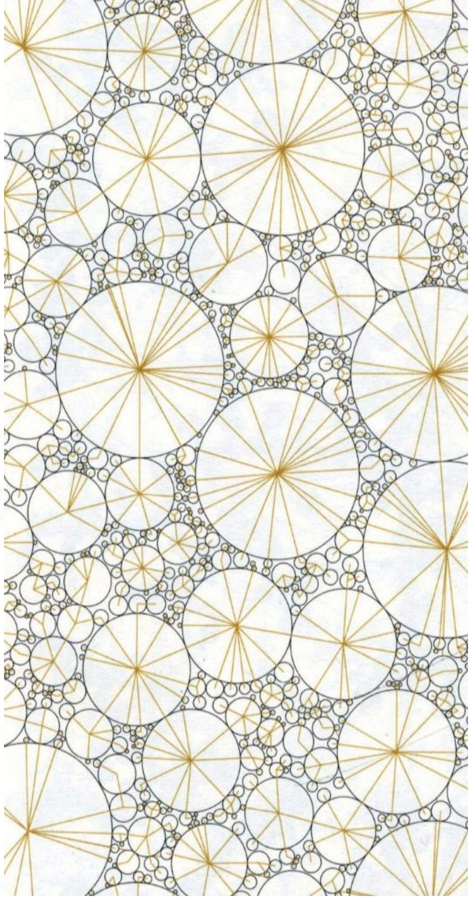
Goal - achieve density by packing circles as closely as possible

Method:

1. Generate a circle
2. Does the circle intersect another circle?

   [yes]
3. Generate a new circle





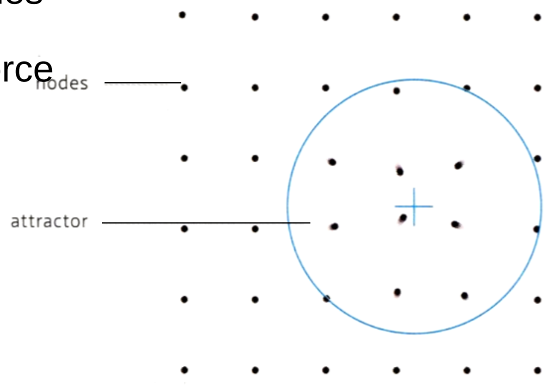
SOURCE: Bohnacker, et al (2012)

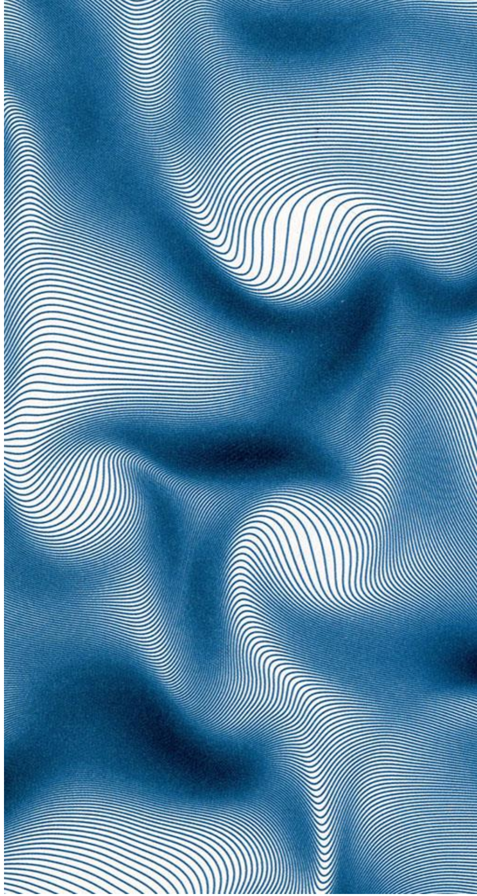
EXAMPLE: USING ATTRACTORS

Goal – gradually deform a series of horizontal lines

Method:

1. Create a grid of nodes
2. Connect nodes with horizontal lines
3. Apply an attracting or repelling force





SOURCE: Bohnacker, et al (2012)

A Methodology for Total Hospital Design

by Gerald L. Delon

A procedure is described that integrates three techniques into a unified approach: a computerized method for estimating departmental areas and construction costs, a computerized layout routine that produces a space-relationship diagram based on qualitative factors, and a second layout program that establishes a final layout by a series of iterations. The methodology described utilizes as input the results of earlier phases of the research, with the output of each step in turn becoming the input for the succeeding step. The method is illustrated by application to a hypothetical pediatric hospital of 100 beds.

Fall 1970

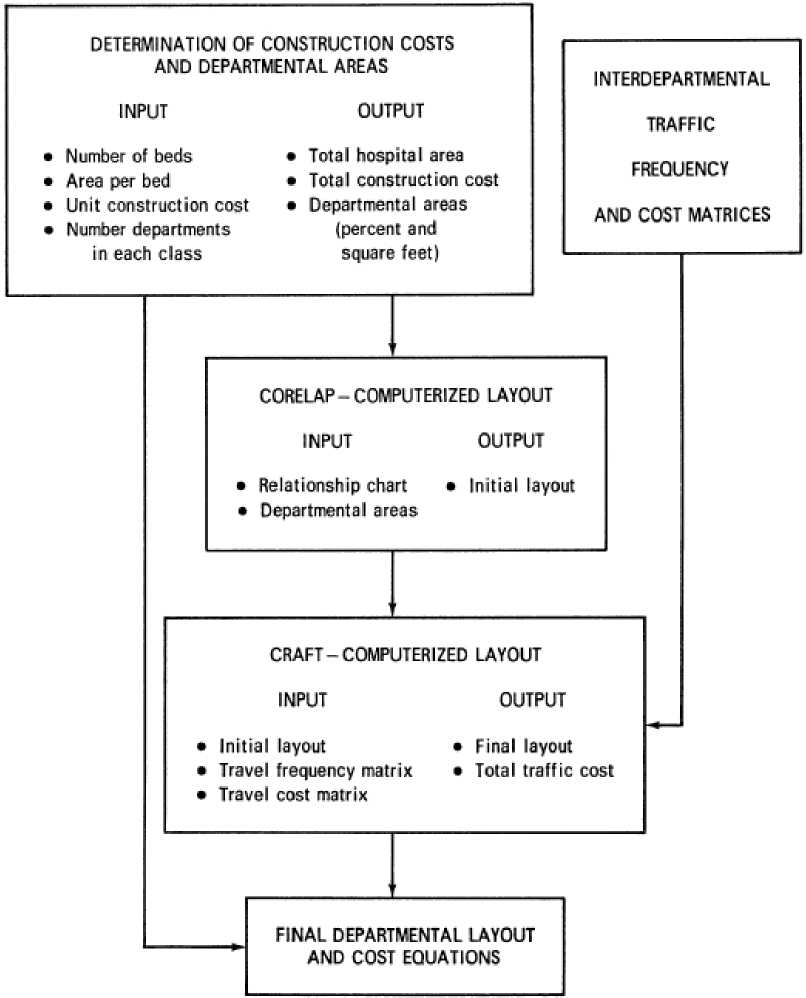
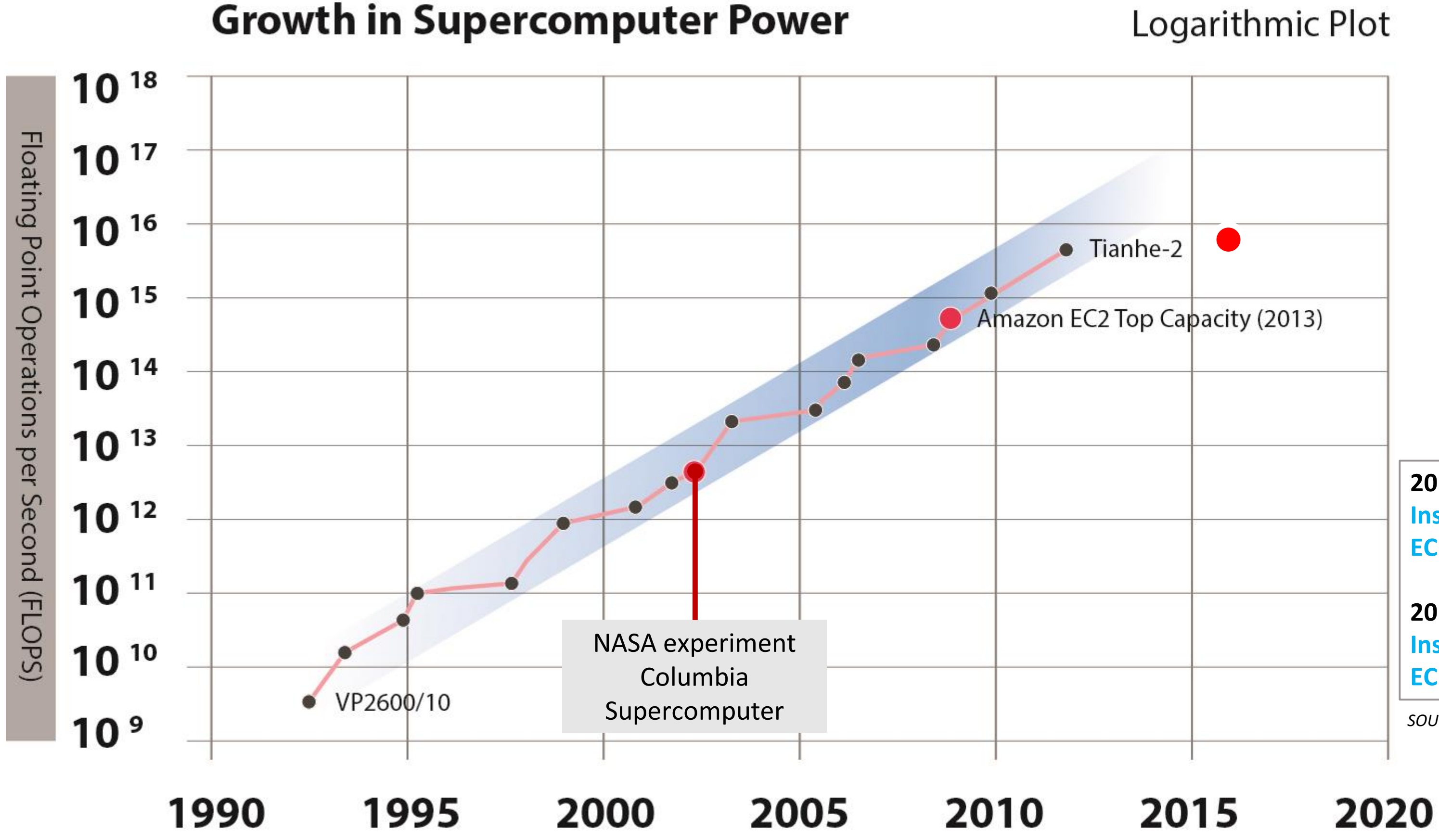


Fig. 1. Flow diagram of methodology for total hospital design.

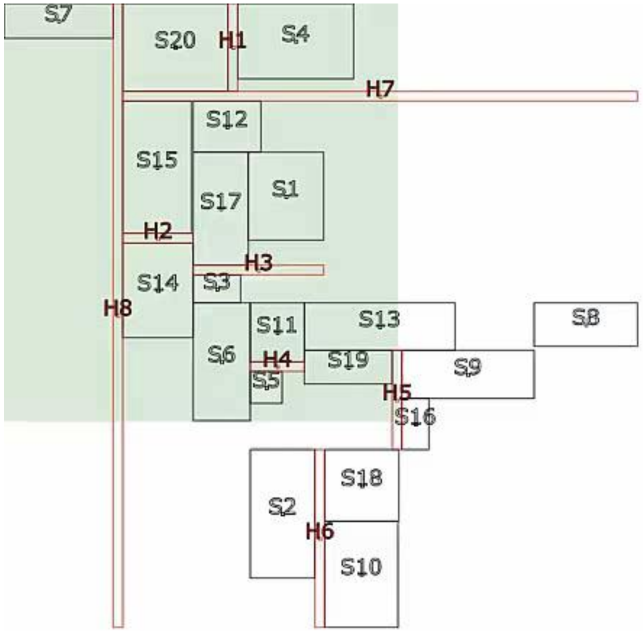
Growth in Supercomputer Power



2010 | 63 Teraflops = 300 Instance Cluster On Amazon EC2

2016 | 354 Teraflops = 1000 Instance Cluster On Amazon EC2

SOURCE: Autodesk



SOURCE: Autodesk

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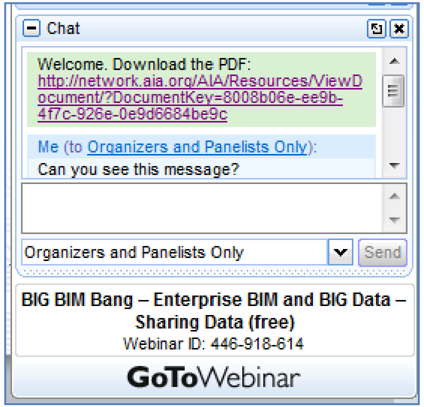
Upcoming Break for Questions and Comments

Submit a question to the moderator via the chat box.



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RESEARCH IN APPLICATIONS OF COMPUTATIONAL DESIGN

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DSC DESIGN SPACE CONSTRUCTION

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CHALLENGES

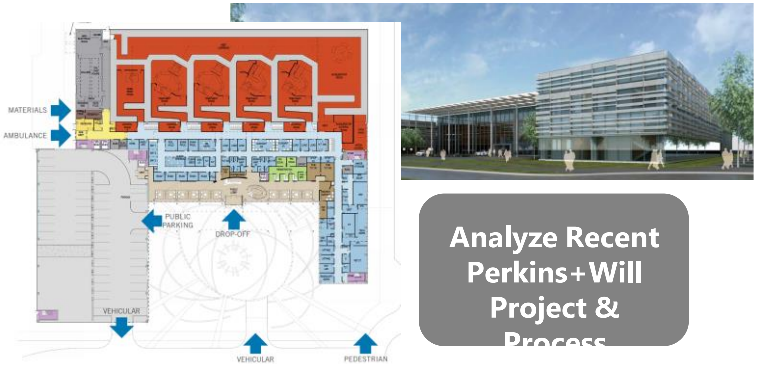
PAST PROJECTS

HOW IT WORKS

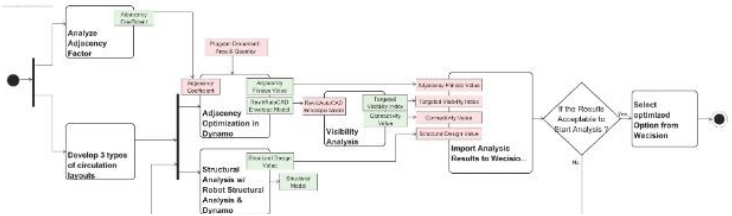
DSC ACADEMY

PERKINS+WILL

2015 PROJECT
Healthcare Planning



Analyze Recent Perkins+Will Project & Process



Plan, Develop Advanced Process

PROFESSORS


Chuck Eastman
Professor G-tech
Digital Building


Fried Augenbroe
Professor G-tech
High-Performance


Craig Zimring
Professor G-tech
Health+Design

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Adetania Pramanik
PhD Candidate in Health+Design


Sammy Shams
PhD Candidate in Health+Design


Samaneh Zolfagharian
PhD Candidate in Building Construction

PERKINS+WILL


John Haymaker
Professor G-tech
Director of Research


Diana Davis
Architect

AUTODESK


Anthony Hauck
Space Planning


Mehdi Nourbakhsh
Performance Analysis


Colin McCrone
Dynamo


Michael Bergin
Computational Design


Mohammad Asl
Optimization

SPACE PLAN GENERATOR

purpose / hypothesis

Create a visual programming-based tool for generating multiple design ideas for evaluation and testing.

SUBAJIT DAS
PhD Candidate
Georgia Tech

PERKINS+WILL

Why Dynamo?

- visual programming interface (uses graphics to describe workflow rather than code)
- more applicable to AEC industry problems
- direct link to Revit

SPACE PLAN GENERATOR
use cases

1. Quickly generate massing options
2. Understand program fitness to site
3. Validate program documents
4. Compare space plans by scoring against set goals
5. Generate space plan data to implement machine learning
6. Export labelled space plans to drawings (.dwg)

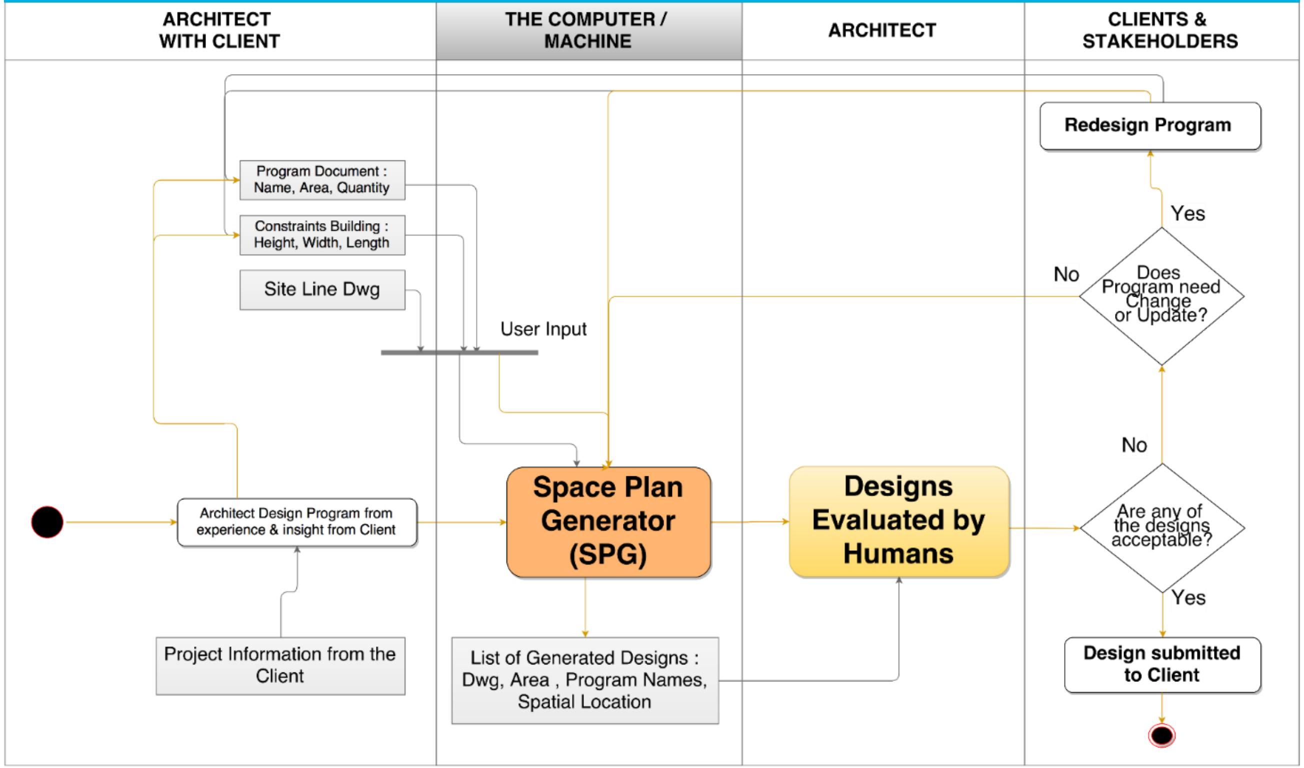
SPACE PLAN GENERATOR

expectations / limitations

- Provide virtually unlimited options with rapid generation time
- Contribute to early massing and departmental adjacency studies

- **NOT** a final floorplan generator

SPACE PLAN GENERATOR WORKFLOW



SOURCE: Das, et al (2016)

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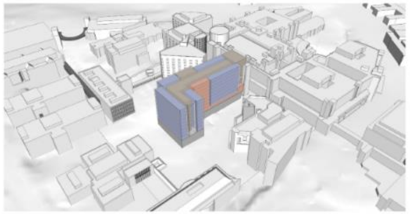
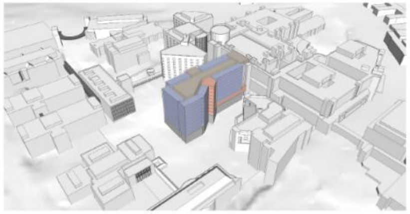
SPACE PLAN GENERATOR
case study

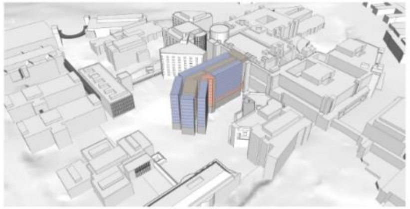
Academic Medical Center bed tower addition on a restricted site



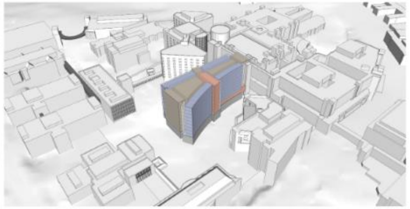
OPTION A



OPTION B



OPTION C



OPTION D

Client Goals:

- Maximize bed count
- Maximize connectivity
- Minimize view corridor impact

SPACE PLAN GENERATOR
case study

What makes a plan efficient and successful?

- Improve net-to-gross ratio / minimize circulation
- Allocate shared support spaces by balancing travel distance against redundancy
- Provide good accessibility to programmed spaces
- Preserve access to daylight and views

SPACE PLAN GENERATOR

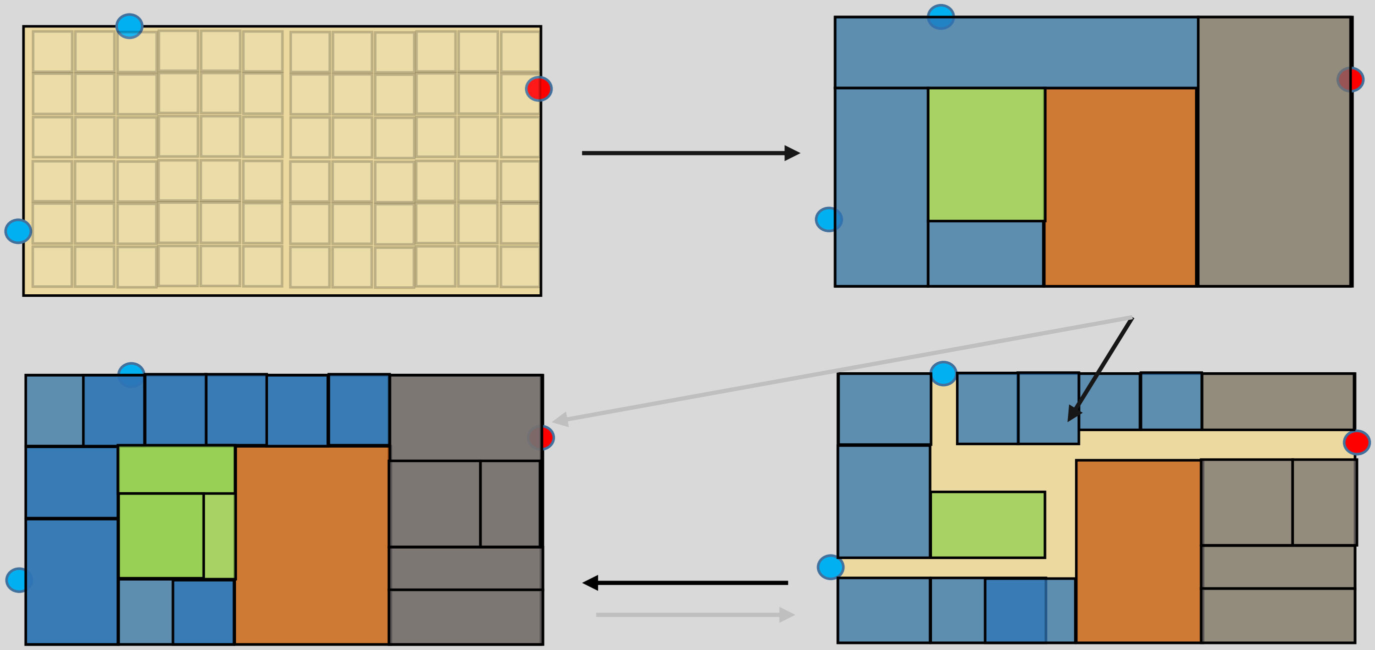
methodology

ASSIGN ENTRIES

LOCATE DEPARTMENTS

INFILL PROGRAM

PLACE CIRCULATION

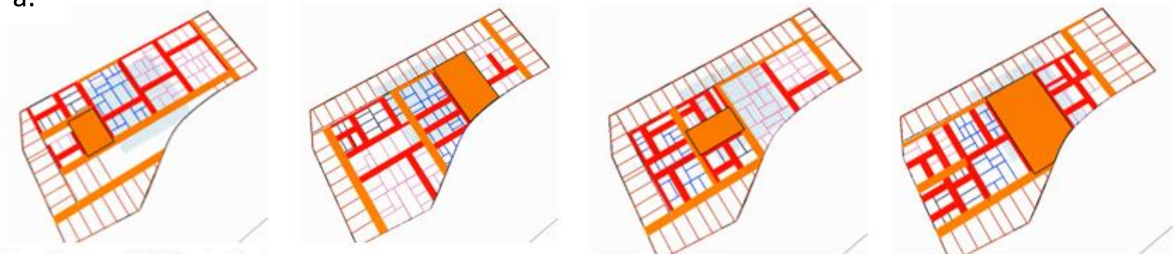


SPACE PLAN GENERATOR

methodology

WITHOUT FORM MAKER

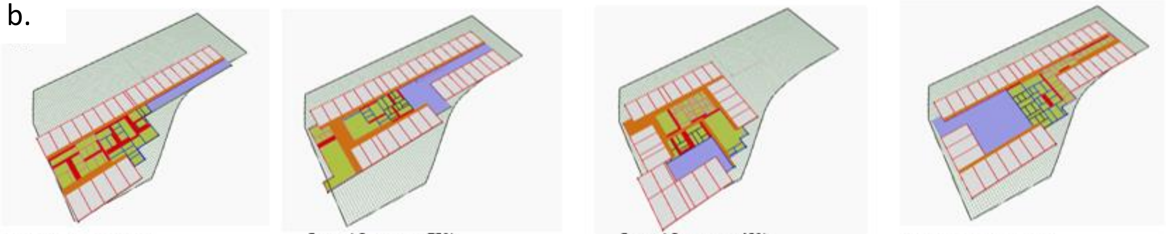
a.



Ground Coverage : 100% (for all options)

WITH FORM MAKER

b.



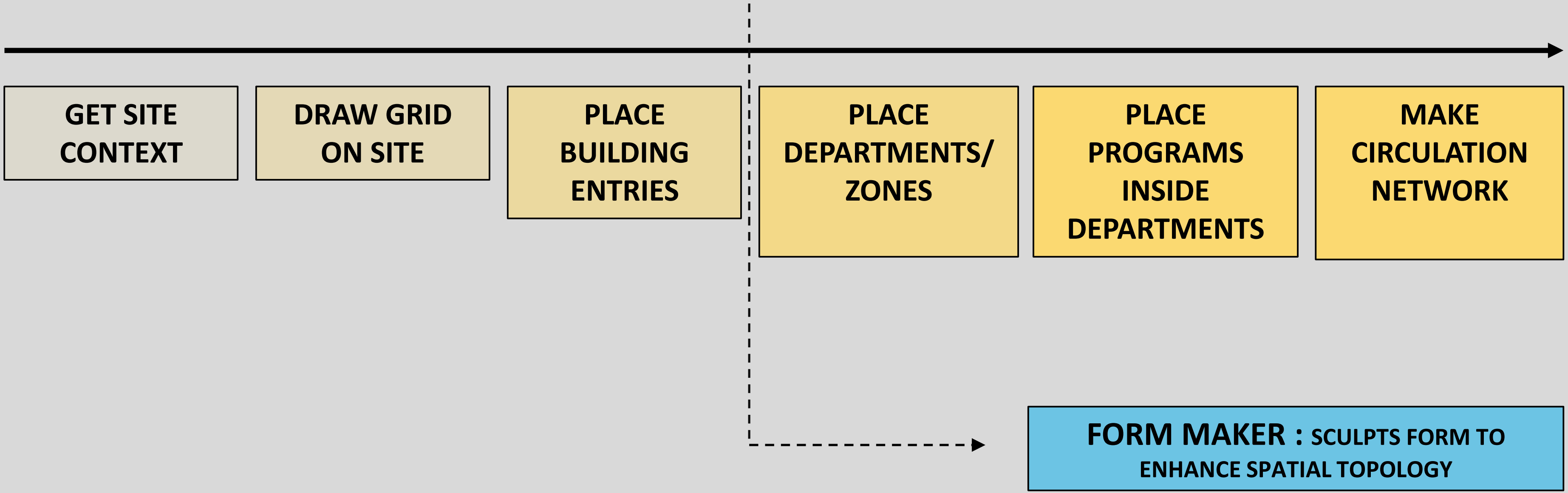
Ground Coverage : 65%

Ground Coverage : 73%

Ground Coverage : 42%

Ground Coverage : 78%

SPACE PLAN GENERATOR
methodology



SPACE PLAN GENERATOR

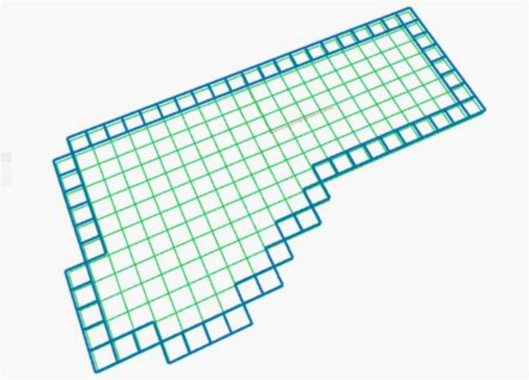
case study

STRATEGY 1 (*Function follows Form*) :

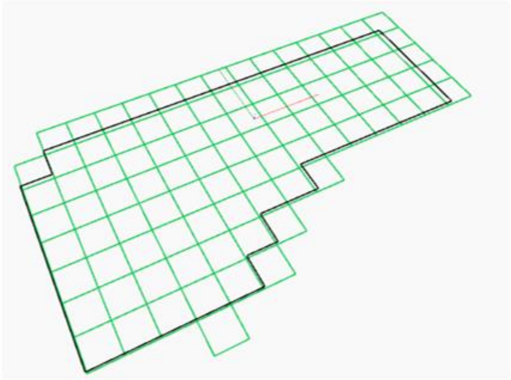
make wholesome blocks and use a combination of the same to assign spaces

STRATEGY 2 (*Form follows Function*) :

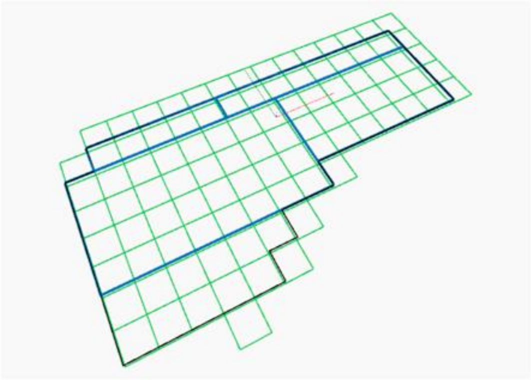
place inpatient blocks and check for external wall, if found proceed, in the end remove unwanted areas



Border Cells from Cell Neighbor Matrix



Finds Border Outline for any Curved Site Outline



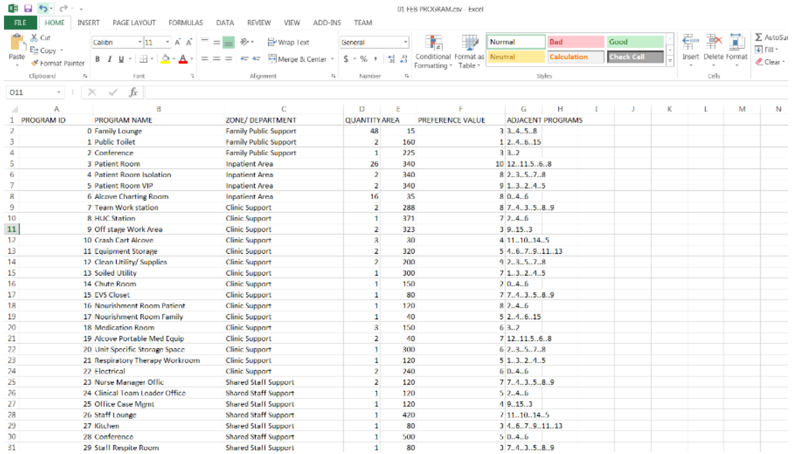
Finds Wholesome (4 sided) polylines and merges them together to make building form

SPACE PLAN GENERATOR

inputs

PROGRAM DATA (*.CSV file*) :

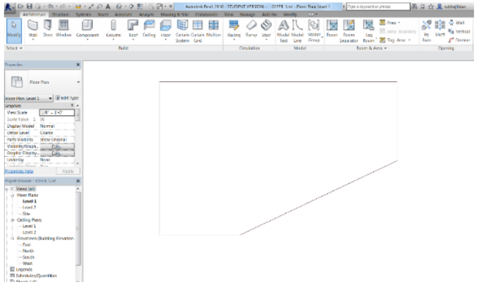
Tabulation of program information with adjacency and priority values

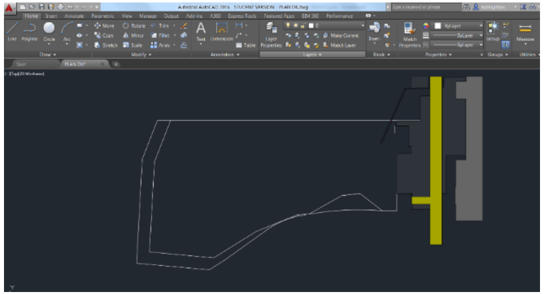


PROGRAM ID	PROGRAM NAME	ZONE/ DEPARTMENT	QUANTITY	AREA	PREFERENCE VALUE	ADJACENT PROGRAMS
0	Family Lounge	Family Public Support	48	15	3	3..4..5..8
1	Public Toilet	Family Public Support	2	160	1	2..4..6..15
2	Conference	Family Public Support	1	225	3	3..2
3	Patient Room	Inpatient Area	26	340	10	12..11.5..6..8
4	Patient Room Isolation	Inpatient Area	2	340	8	2..3..5..7..8
5	Patient Room VIP	Inpatient Area	2	340	9	1..3..2..4..5
6	Alcove Charting Room	Inpatient Area	16	35	8	0..4..6
7	Team Work station	Clinic Support	2	288	8	7..4..3..5..8..9
8	HUC Station	Clinic Support	1	371	7	2..4..6
9	Off stage Work Area	Clinic Support	2	323	3	9..15..3
10	Crash Cart Alcove	Clinic Support	3	30	4	11..10..14..5
11	Equipment Storage	Clinic Support	2	320	5	4..6..7..9..11..13
12	Clean Utility/ Supplies	Clinic Support	2	200	9	2..3..5..7..8
13	Soiled Utility	Clinic Support	1	300	7	1..3..2..4..5
14	Chute Room	Clinic Support	1	150	2	0..4..6
15	EVS Closet	Clinic Support	1	80	7	7..4..3..5..8..9
16	Nourishment Room Patient	Clinic Support	1	120	8	2..4..6
17	Nourishment Room Family	Clinic Support	1	40	5	2..4..6..15
18	Medication Room	Clinic Support	3	150	6	3..2
19	Alcove Portable Med Equip	Clinic Support	2	40	7	12..11.5..6..8
20	Unit Specific Storage Space	Clinic Support	1	300	6	2..3..5..7..8
21	Respiratory Therapy Workroom	Clinic Support	1	120	5	1..3..2..4..5
22	Electrical	Clinic Support	2	240	6	0..4..6
23	Nurse Manager Offic	Shared Staff Support	2	120	7	7..4..3..5..8..9
24	Clinical Team Leader Office	Shared Staff Support	1	120	5	2..4..6
25	Office Case Mgmt	Shared Staff Support	1	120	4	9..15..3
26	Staff Lounge	Shared Staff Support	1	420	7	11..10..14..5
27	Kitchen	Shared Staff Support	1	80	3	4..6..7..9..11..13
28	Conference	Shared Staff Support	1	500	5	0..4..6
29	Staff Respite Room	Shared Staff Support	1	80	3	7..4..3..5..8..9

SITE OUTLINE (*.SAT file*) :

Outline of site boundary from CAD

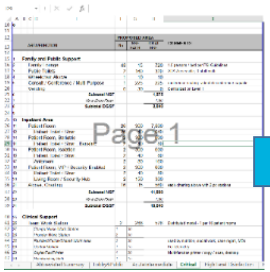




PERKINS+WILL

SPACE PLAN GENERATOR

inputs



PROGRAM ID	PROGRAM NAME	ZONE/ DEPARTMENT	QUANTITY	AREA	PREFERENCE VALUE	ADJACENT PROGRAMS
0	Family Lounge	Family Public Support	48	15	3	3..4..5..8
1	Public Toilet	Family Public Support	2	160	1	2..4..6..15
2	Conference	Family Public Support	1	225	3	3..2
3	Patient Room	Inpatient Area	26	340	10	12..11.5..6..8
4	Patient Room Isolation	Inpatient Area	2	340	8	2..3..5..7..8
5	Patient Room VIP	Inpatient Area	2	340	9	1..3..2..4..5
6	Alcove Charting Room	Inpatient Area	16	35	8	0..4..6
7	Team Work station	Clinic Support	2	288	8	7..4..3..5..8..9
8	HUC Station	Clinic Support	1	371	7	2..4..6
9	Off stage Work Area	Clinic Support	2	328	3	9..15..3
10	Crash Cart Alcove	Clinic Support	3	30	4	11..10..14..5
11	Equipment Storage	Clinic Support	2	320	5	4..6..7..9..11..13
12	Clean Utility/ Supplies	Clinic Support	2	200	9	2..3..5..7..8
13	Soiled Utility	Clinic Support	1	300	7	1..3..2..4..5
14	Chute Room	Clinic Support	1	150	2	0..4..6
15	EVS Closet	Clinic Support	1	80	7	7..4..3..5..8..9
16	Nourishment Room Patient	Clinic Support	1	120	8	2..4..6
17	Nourishment Room Family	Clinic Support	1	40	5	2..4..6..15
18	Medication Room	Clinic Support	3	150	6	3..2
19	Alcove Portable Med Equip	Clinic Support	2	40	7	12..11.5..6..8
20	Unit Specific Storage Space	Clinic Support	1	300	6	2..3..5..7..8
21	Respiratory Therapy Workroom	Clinic Support	1	120	5	1..3..2..4..5
22	Electrical	Clinic Support	2	240	6	0..4..6

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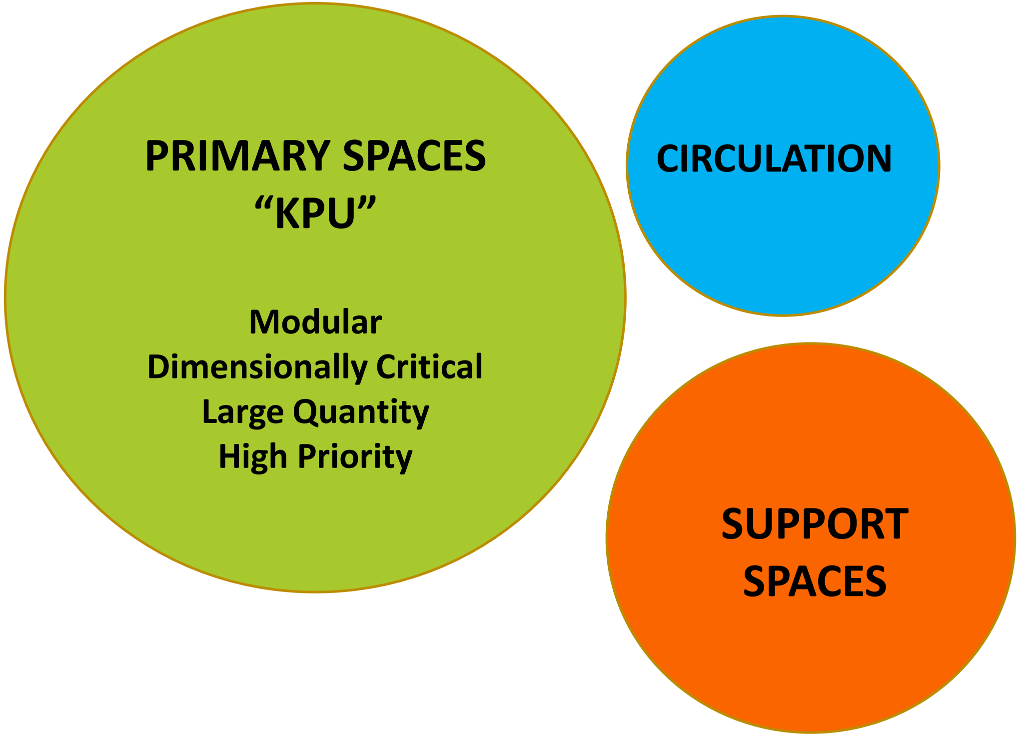
SPACE PLAN GENERATOR
inputs

KEY PLANNING UNITS (KPU)

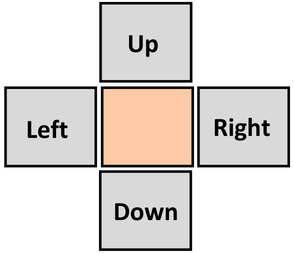
Hospital : patient rooms , exam rooms, research labs,
School : classrooms, research labs
Hotel : guest rooms, suites, rooms
Offices : closed office space, meeting rooms
Shopping Malls : retail showrooms, anchor showrooms , small shops
Convention Centers : exhibition halls, conference rooms, banquet halls
Museums : galleries, exhibition areas.
Residential : apartments, bedrooms, suites



SPACE PLAN GENERATOR
inputs

CELL TRAVERSAL

- **Go Right, Then**
- **Go Up,**
- **Go Left, and**
- **Go Down**



CELL AVAILABILITY

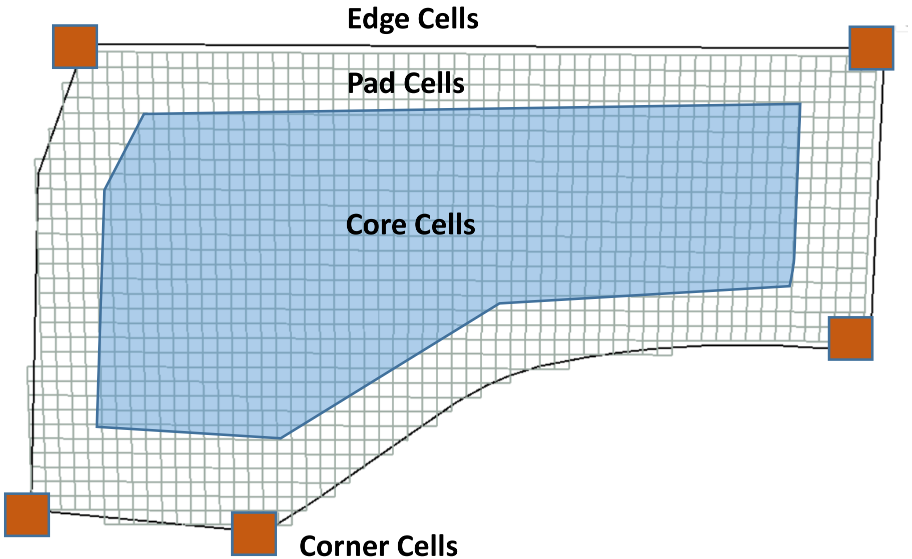
[01] : true
[02] : false
[03] : true

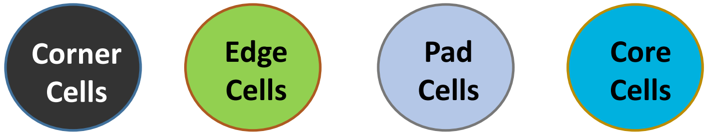
CELL WEIGHTAGE

[01] : 5
[02] : 2
[03] : 1

Weights for:

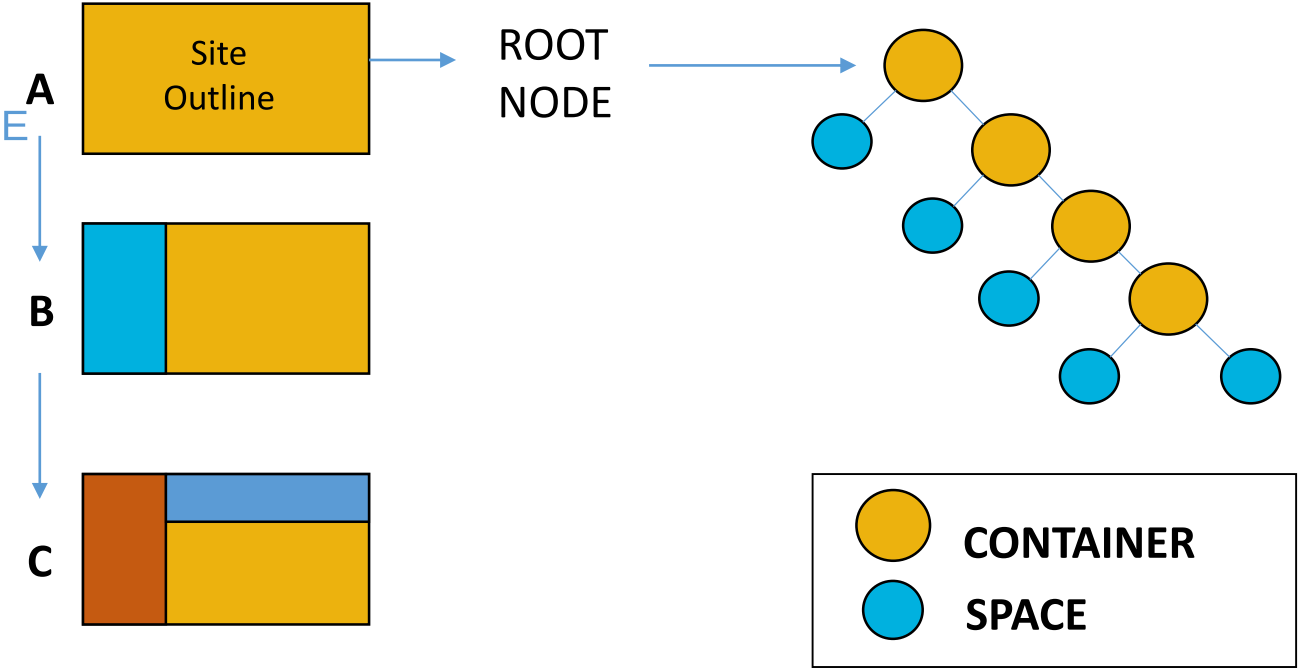
- Acoustics
- Daylighting
- Views
- Direction





SPACE PLAN GENERATOR
data structure

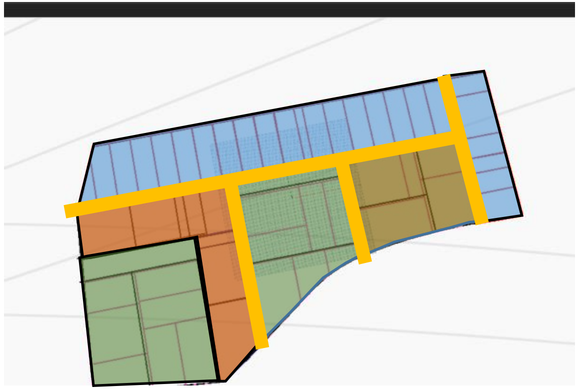
K-D TREE STRUCTURE
- Container
- Space
- Outline



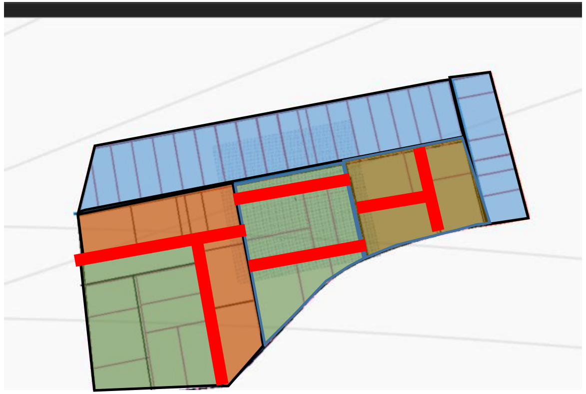
SPACE PLAN GENERATOR

data structure

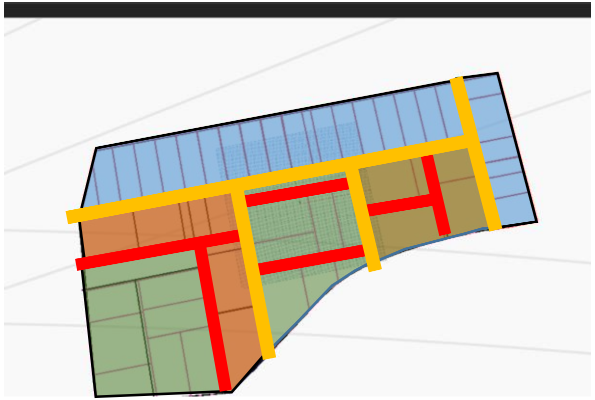
CIRCULATION STRATEGY



1. Shared Edges Between Nearest Departments



2. Shared Edges Between Neighbor Programs inside Departments



3. Combines the two circulation networks after redundancy check

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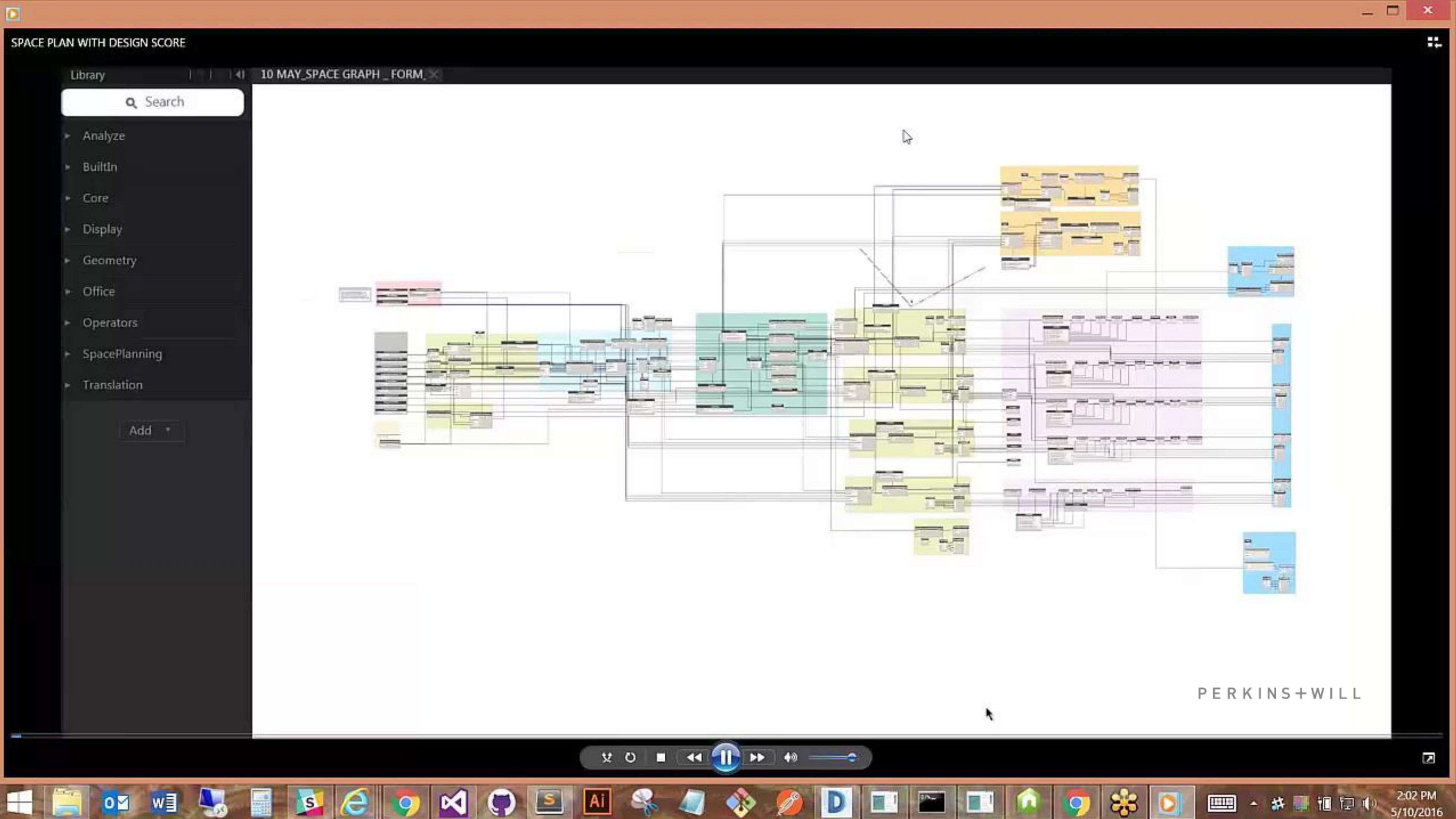
SPACE PLAN GENERATOR
inputs – 3D visualization

BUILDING HEIGHT
Total available vertical height for placing program departments

BUILDING LEVEL HEIGHT
Minimum floor-to-floor height

DEPARTMENTS PER LEVEL
Sets number of desired departments per level



SPACE PLAN WITH DESIGN SCORE
Library
10 MAY_SPACE GRAPH _ FORM_
Search
Analyze
BuiltIn
Core
Display
Geometry
Office
Operators
SpacePlanning
Translation
Add
PERKINS+WILL
2:02 PM
5/10/2016

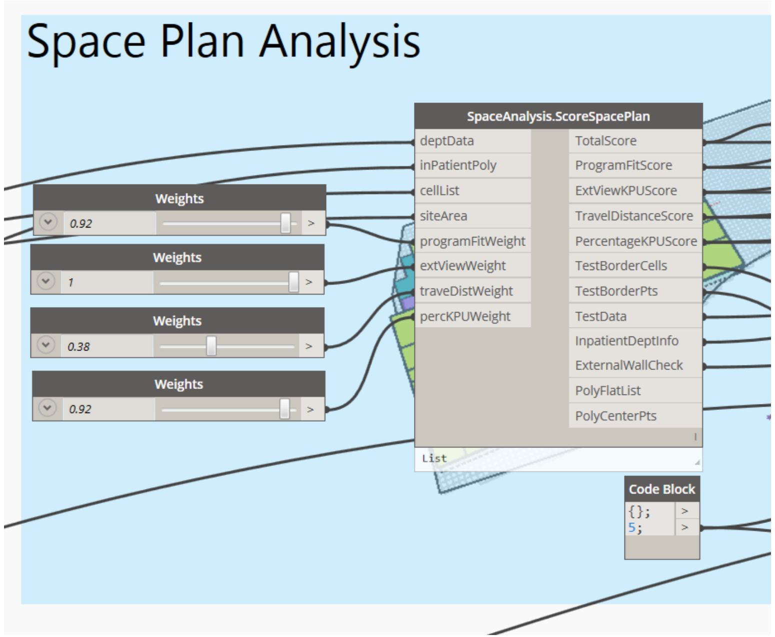
SPACE PLAN GENERATOR
inputs

PROGRAM FIT WEIGHT
Prioritize for accommodation of all program

EXTERIOR VIEW WEIGHT
Prioritize for KPUs having exterior view

TRAVEL DISTANCE WEIGHT
Prioritize to shorten average distance from support space to KPUs

KPU PERCENT WEIGHT
Prioritize for what percentage of the floor is taken up with KPUs



SPACE PLAN GENERATOR

outputs and scoring

PROGRAM FIT SCORE

Describes what proportion of program was placed in the site outline

EXTERNAL VIEW SCORE

Describes what proportion of KPUs have exterior view potential

TRAVEL DISTANCE SCORE

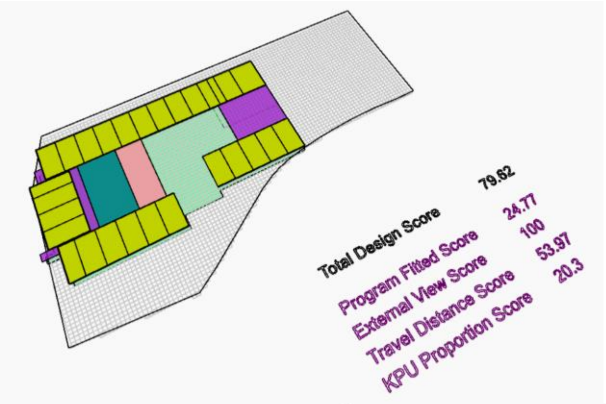
Describes average distance from support space to KPUs

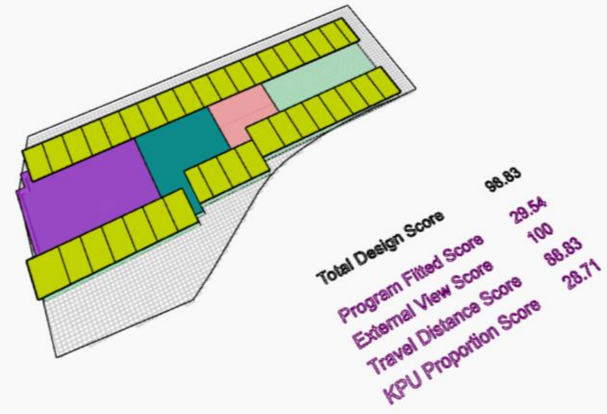
KPU PROPORTION SCORE

Describes what percentage of the floor is taken up with KPUs

KPU NUMBER

Describes total KPU count





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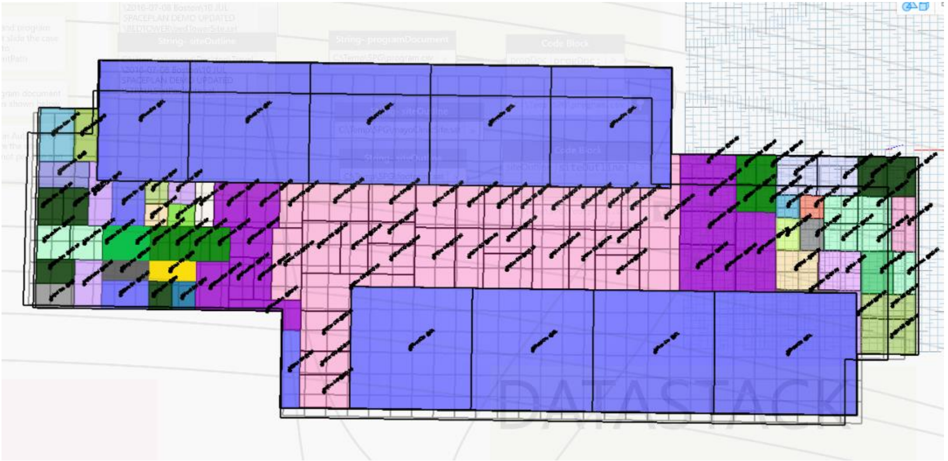
SPACE PLAN GENERATOR
planning workshop

- Two person teams from across firm
  - Healthcare Planner
  - Computational Designer
- Two day workshop
  - Training / Background
  - Testing the tool
  - Feedback / Next Steps

SPACE PLAN GENERATOR

planning workshop

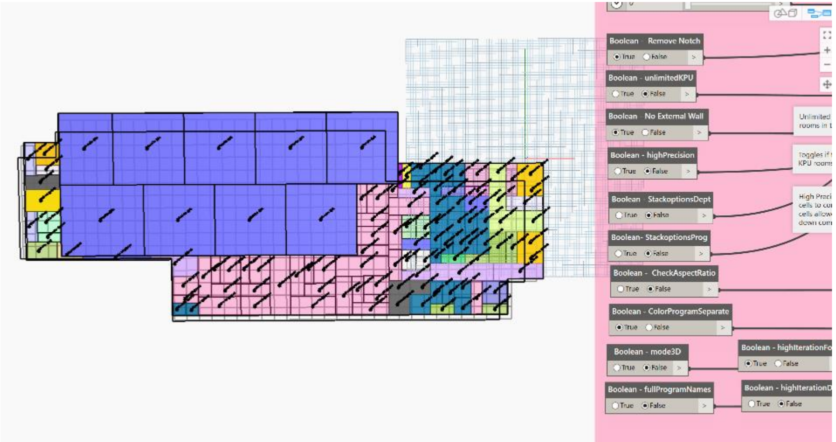
ACTUAL PL



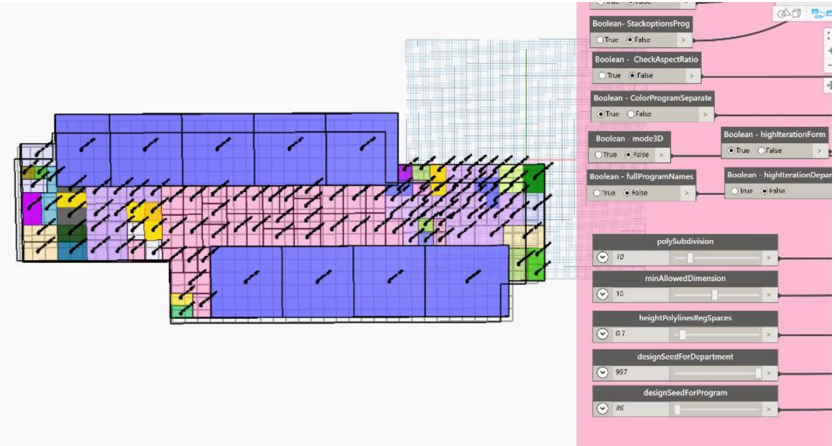
BEST SPG P

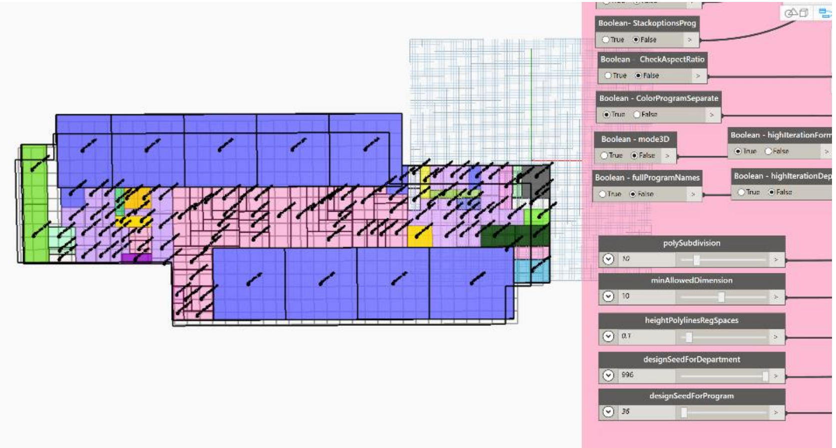
SPACE PLAN GENERATOR

planning workshop



OTHER PL





SPACE PLAN GENERATOR

planning workshop

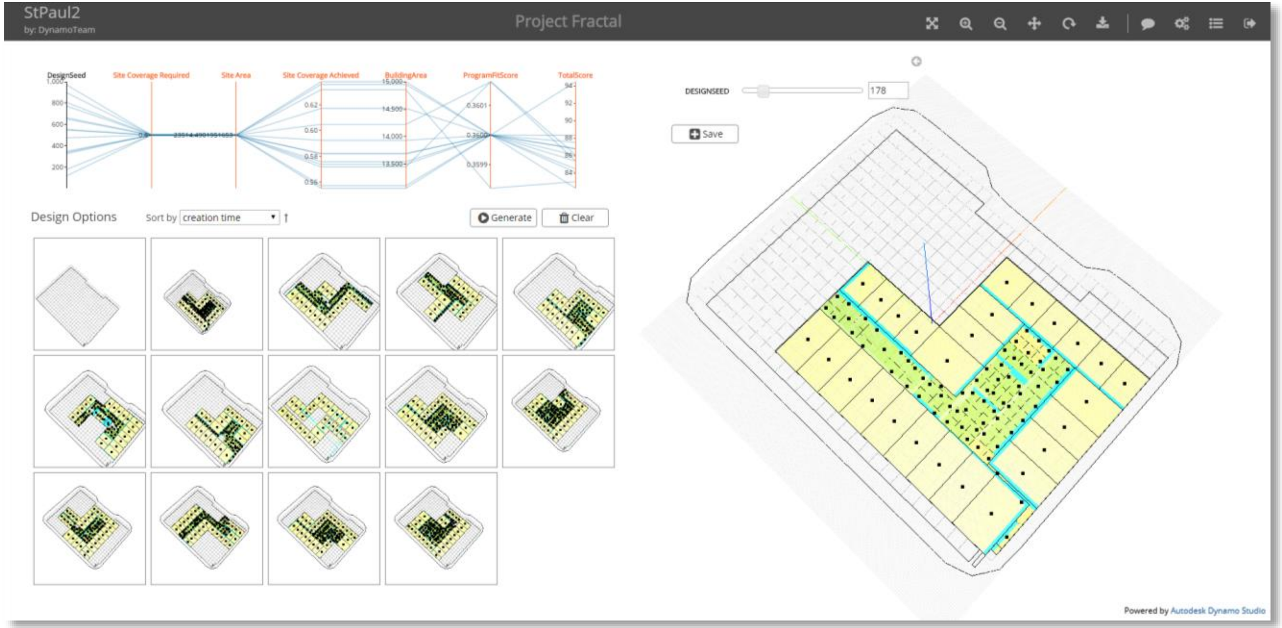
ACTUAL PL

Total Design Score	80.41
Program Fitted Score	25.7
External View Score	100
Travel Distance Score	52.19
KPU Proportion Score	23.13
Number of KPU Rooms	89

BEST SPG P

SPACE PLAN GENERATOR

Software prototyped by Autodesk, tested on SPG



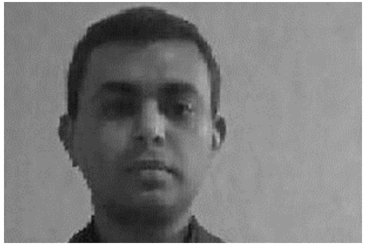
Autodesk | PERKINS+WILL | Georgia Institute of Technology

TAKE 2: SPACE PLAN GENERATOR

purpose / hypothesis

Explore further how to:

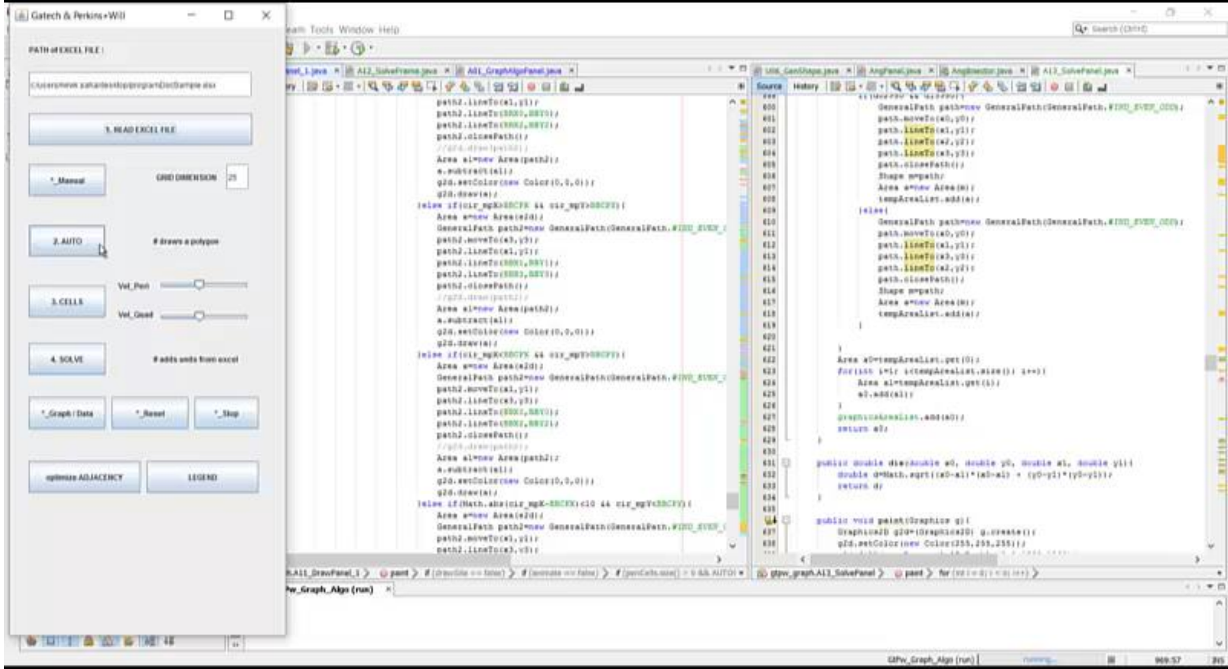
- Address more complex building typologies,
- Decompose the process into useful components,
- Optimize.



Nirvik Saha
PhD Student
Digital Building Lab
Georgia Tech

SPACE PLAN GENERATOR

next steps



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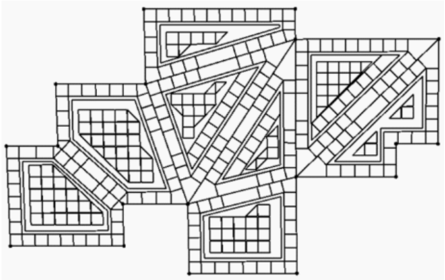
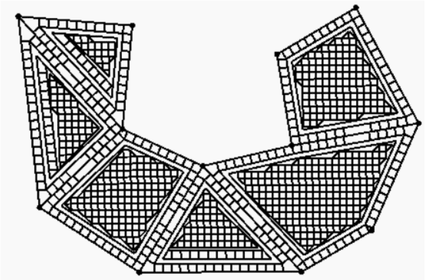
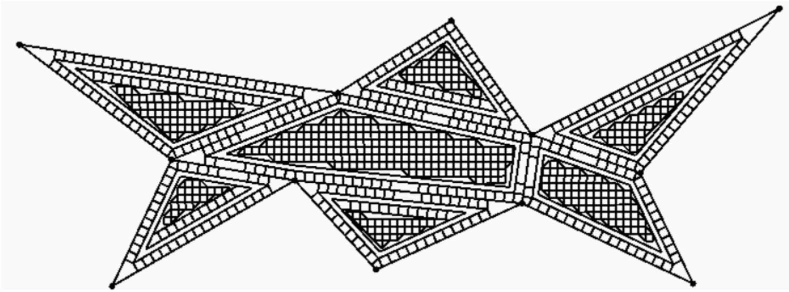
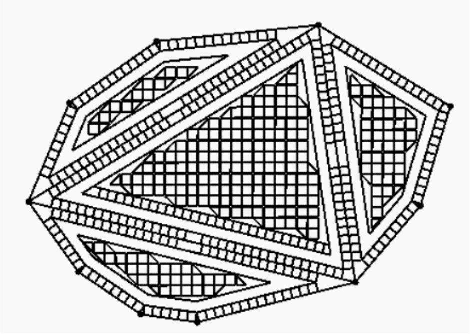
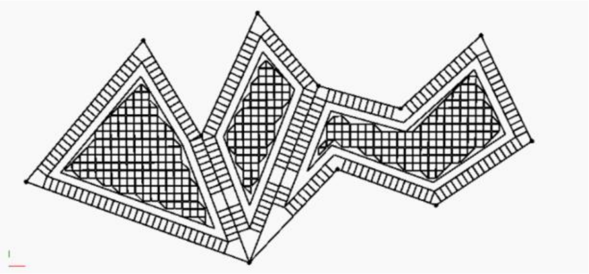
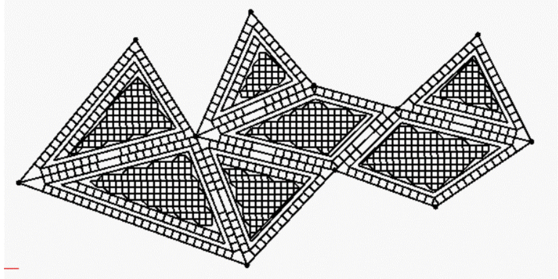




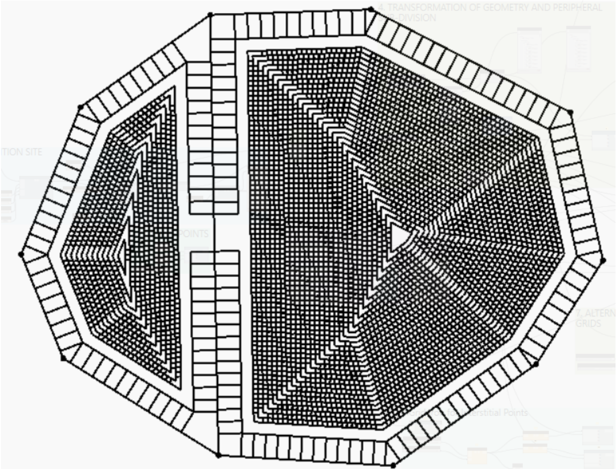


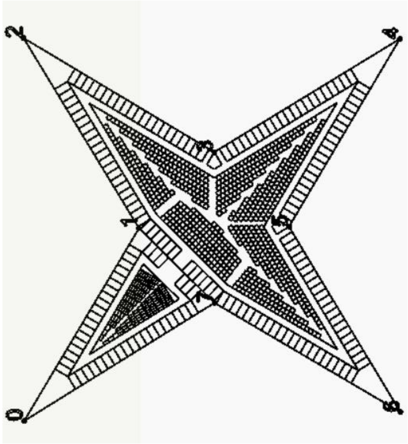


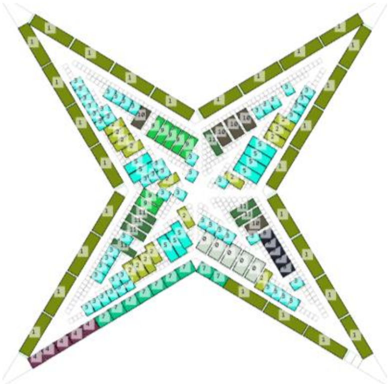




Complete solution: development of cells







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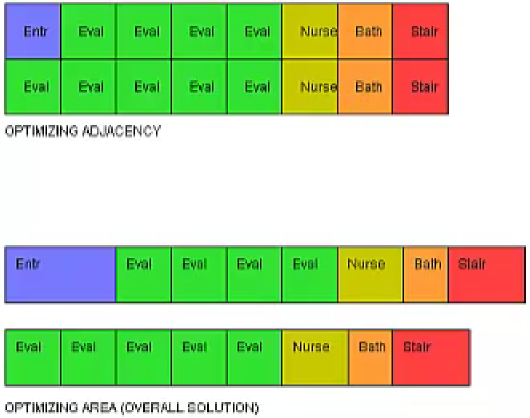
SPACE PLAN GENERATOR

optimization algorithms

Optimization of Double-loaded corridor



SI.No	Entr	Eval	Nurse	Bath	Stairs
Entr	1	05	05	05	05
Eval	X	10	05	00	00
Nurse	X	X	-50	00	00
Bath	X	X	X	-50	1000
Stairs	X	X	X	X	-50

UID	Name	Area	Number	Color
0	Entr	500	1	128,128,255
1	Eval	120	5	50,255,50
2	Nurse	80	2	200,200,0
3	Bath	200	2	255,155,55
4	Stairs	100	2	255,64,64

RUN ITERATION   INITIATE ITERATION

Click Counter : 0   Current Fitness (minimize) : 113597.63247814265   Number of iterations(max=100) : 0

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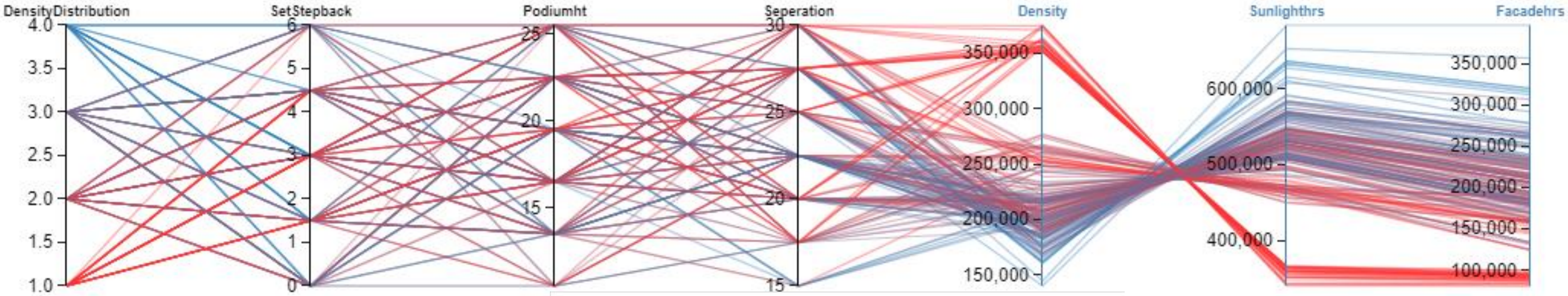
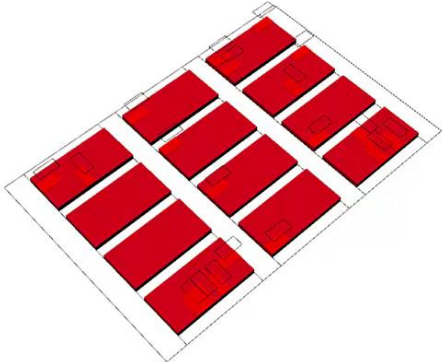
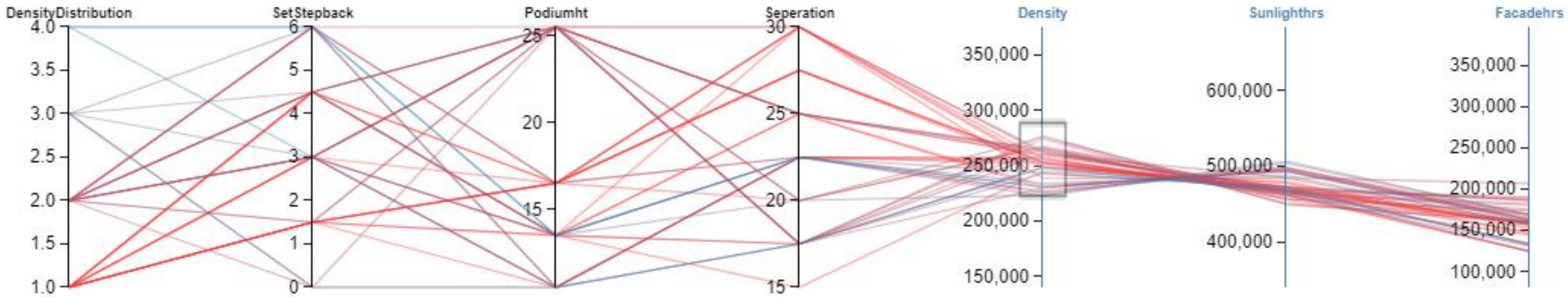
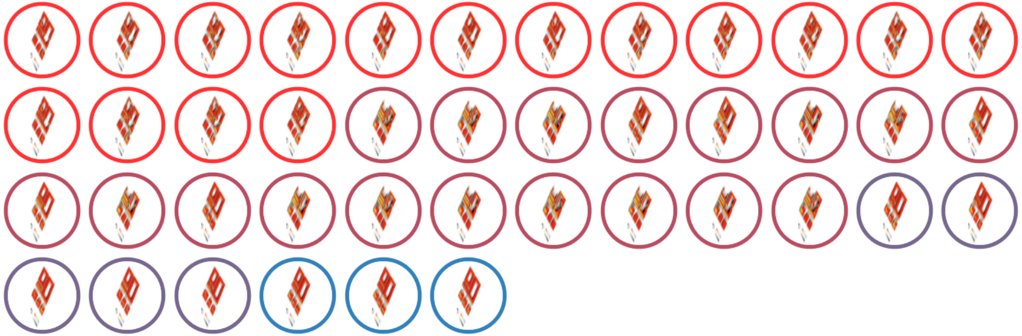
APPLICATION – URBAN FORM OPTIMIZATION





URBAN FORM OPTIMIZATION





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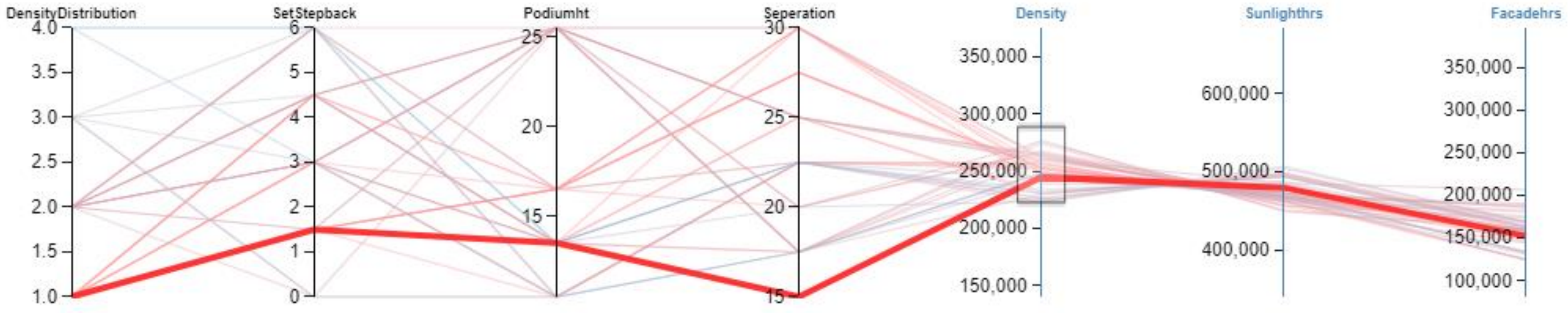
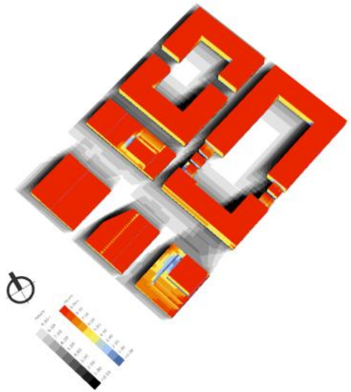
APPLICATION – TORONTO





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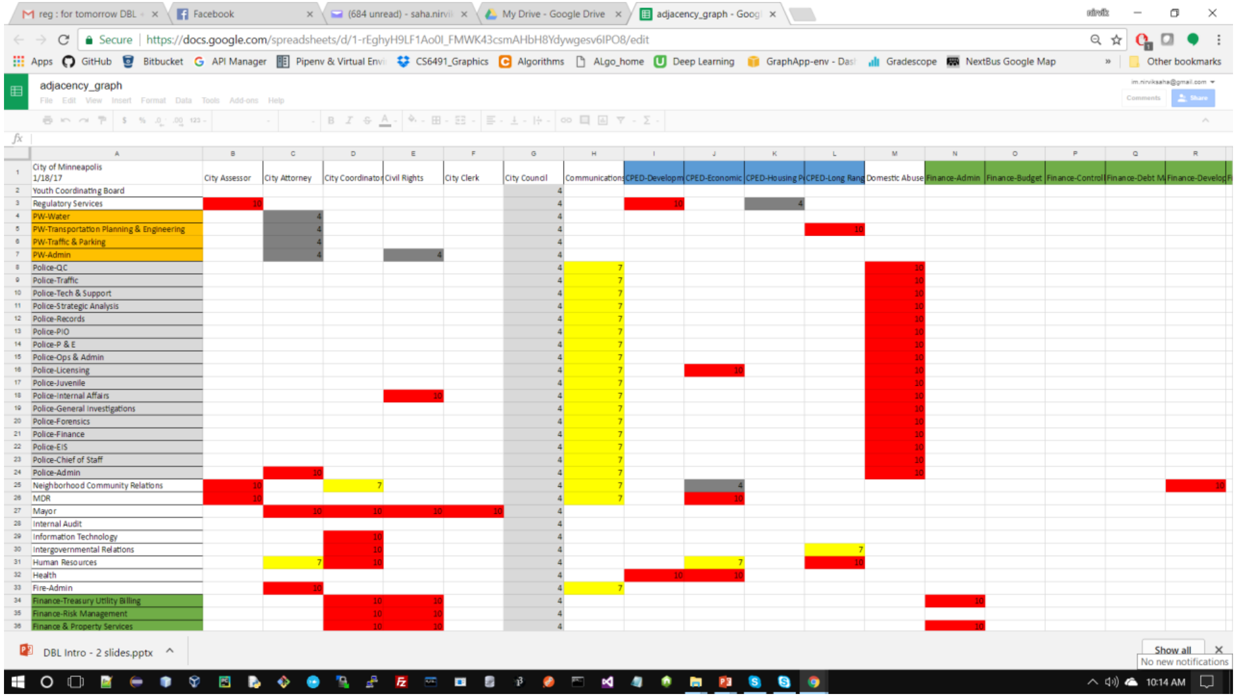
SPACE PLAN GENERATOR

Program Analyzer - Input Program



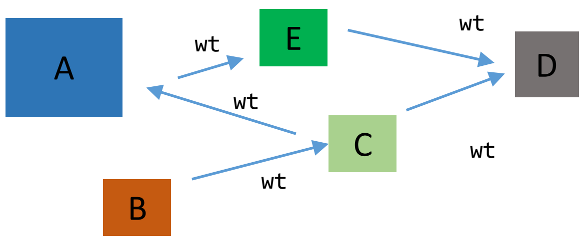
SPACE PLAN GENERATOR

Program Analyzer - Force and Tree layouts

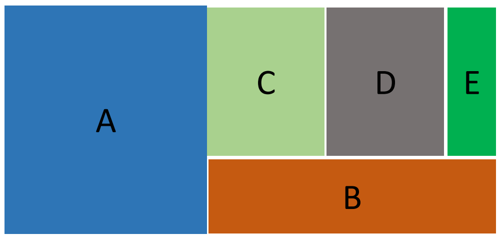
Input for Plotting connections		
Source :Name of Node	Target : Name of connected Node	Weight of connection (Value)
NodeObj A	Node E	12
Node B	Node C	20
Node C	Node A	34

Input for size of object	
Name of Node	Head Count
Node A	80
Node B	50
Node C	12
Node D	7
Node E	40

Force Layout



Treemap Layout



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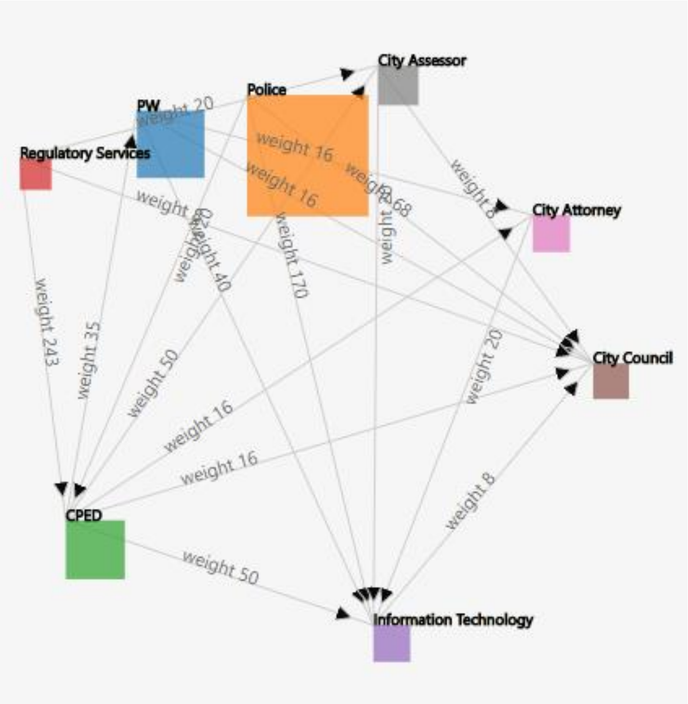
Force Layout



Treemap Layout

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DSC DESIGN SPACE CONSTRUCTION

Home About Log In

CHALLENGES

PAST PROJECTS

HOW IT WORKS

DSC ACADEMY

SOURCES:

Das, Subhajit, et al. "*Space Plan Generator: Rapid Generation and Evaluation of Floor Plan Design Options to Inform Decision Making*." Acadia Conference: Ann Arbor, Michigan 2016.

Bohnacker, Harmut, et al. *Computational Design: Visualize, Program, and Create with Processing*. Princeton Architectural Press, 2012.

"Diagramming Machines: Writings on Computational and Computational Design." http://www.reneepuusepp.com/what-is-Computational-design

"Computational Design." *Wikipedia: The Free Encyclopedia*. Wikimedia Foundation, Inc., 25 Aug. 2016. Web 7 Sept. 2016. http://en.Wikipedia.org/wiki/Computational_Design

AEC Computational Design Team, Autodesk, Inc. (2016).

RESOURCES:

http://research.perkinswill.com

http:designspaceconstruction.org

Das et al. (2016) “*Space Plan Generator: Rapid Generation and Evaluation of Floor Plan Design Options to Inform Decision Making*.” ACADIA Conference: Ann Arbor, Michigan.

Haymaker et al (2017). “Design Space Construction: A Framework To Support Collaborative, Parametric Decision Making” In Press.

Vasanthakumar et al, (2017), “Bibl: A Performance-based Framework to Determine Built Form Guidelines,” ACADIA Conference, Cambridge, MA.

Time for Questions and Comments

???-!!

Moderator
Rita Ho, LEED AP

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Date	Series	Topic
12/19	HC 101 Series	Trends in Medical Planning, Part 1: Following the Thread
02/13	Case Study Series	Enhanced Integration - Changing and Improving Health Facilities Design
03/13	HC 101 Series	Trends in Medical Planning, Part 2: The Inpatient Unit, Weaving the Threads Together

*Dates and topics are subject to change

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