Spatial Configuration Layout Analysis of Commercial Spaces

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***Abstract*—By investigating the effect of spatial configuration on both office productivity and user experience in commercial office layouts this research investigates the relationship between visibility and connecting and movement patterns in two different floor plan designs: axial and radial layouts. The study examines the influence of two different spatial arrangement on the movement, wayfinding and collaboration interface of the office environment from the perspective of Visibility Graph Analysis (VGA) and Agent Graph Simulation. Particular findings are discussed in terms of the advantages and disadvantages of each plan's spatial connectivity and user interaction profile. The axial layout emphasizes a clear and hierarchical flow pattern suitable for structured movement. Meanwhile the radial layout provides more privacy and zoning features promoting specialized functions while challenging navigation. The results of this study indicate that the optimal design provides a balance between centralizing movement with privacy zones generating flexibility and adaptability in space utilization and contributing to a more productive office environment. This research contributes to the understanding of how spatial design affects organizational behavior and the overall productivity of office environments. It also provides insights for architects and designers who wish to design an adaptive, user-centric workspace.**

1. INTRODUCTION

Understanding Axial and Radial Planning

An axial plan is the one which organizes spaces along attach straight lines or a straight central axis- this provides a clear-cut direction and hierarchy. It is evidently the approach often taken with temples, churches, palaces et cetera where an axial system traditionally guides movement towards a focus such as an altar or throne. Geometrically, axial arrangements endorse straight lines with strong contenders connecting spaces. Over time, the same idea has been evolving and most of today's plans of buildings are now utilitarian and sometimes call for more than one axis.

By way of axial planning there can be found an easy recognition and extensive import, for this type of structural layout brings together a series of critical spaces along a visible straight pathway. Thus, they lead people from the entrances and through them toward important destinations. It has been prevalent over the ages, from being a traditional idea to that which modern architecture employs to form intuitive, coherent, and easy routes through buildings. Finding examples of it in all kinds of religious buildings, in classical designs of cities like those from the Renaissance period such as Rome itself, and even in contemporary projects where many of the axes organize large complexes.

On the opposite end, radial planning involves a central 'hub' with spaces radiating like spokes of a wheel. It places emphasis on centrality, symmetry, and multiple pathways rather than that of one single path. Radial planning has venerable roots in religious structures, fortified cities, and other symbolic designs whereby the center has been defined as representing power, spirituality, or control. Geometrically speaking, they typically form circles or polygons, allowing movement in all directions equal to that direction.

A radial plan creates an intense core with other spaced-out zones around it. Movement is multidirectional, permitting easy access through different zones. Historically such schemes were used in structures like Buddhist stupas, military forts, or even the ideal city of the Renaissance, and these examples rather reflect the current relevance of radial

planning today. It can be observed it in museums, research campuses, exhibition centers, and collaborative workspaces where a central hub organizes and connects multiple activities.

That is how axial planning conduces to the one finding his way straightly in lines toward important points. Radial planning would rather create a strong central space with several lines running outward. Both these strategies mold and shape the experiences and movements possible through a space-linear tool-journey and clarity, while the other is more about interests of connection, balance, and flexibility.

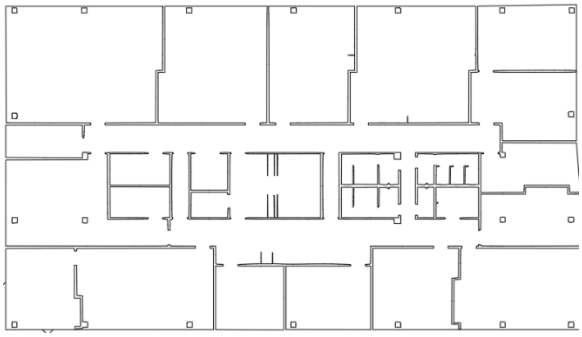

Fig: AXIAL PLAN

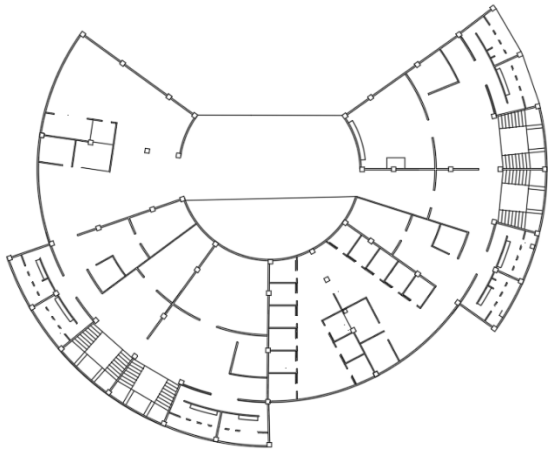

Fig: RADIAL PLAN

2. VISIBILITY GRAPH ANALYSIS (VGA)

The Visibility Graph Analysis (VGA) presents data that illustrates how various spaces within office floor plans perform in terms of visual connectivity. Color coding is employed in the VGA maps to provide a quick visual representation of areas with higher levels of mutual visibility.

Red and Yellow Areas:
These zones typically represent large, open spaces characterized by significant foot traffic and a high degree of visual connection.
like main hallways, circulation areas, or shared open areas.
Green Areas: These are of a moderate scale, also what I would term semi private areas which are open to some degree but not at the forefront.
Blue Areas: These are spaces which do not let in much light, usually of a closed in nature or which have few connections.
Key Observations Common to Both Plans:
High-brightness colors are typically found along primary circulation routes and at gathering points, thereby promoting flow and facilitating wayfinding.
Low-visibility areas (cool colors) tend to exhibit a contained nature, which contributes to privacy and reduces spontaneous visual interaction.
Connectivity Trends:
In most cases, it has been observed that connections between elements diminish with increased distance from central areas. This spatial gradient contributes to the separation of public and private zones.
Wayfinding Potential:
Spaces with higher visibility may be strategically utilized to enhance navigation and foster collaborative interaction across the floor.

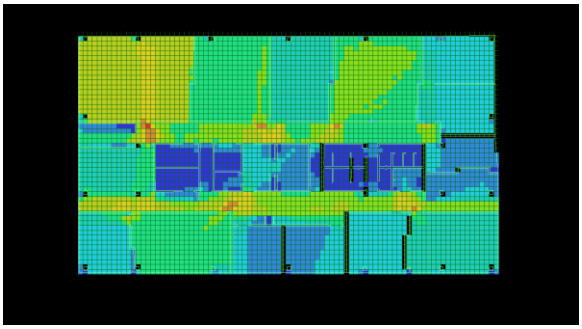

Fig: VGA for axial plan

2.1 Specific Analysis for Axial Plan
Visibility and Movement Patterns: Visibility and Action Trends:
High Visibility: Main hallways and primary movement areas are of high visibility (red/yellow) which in turn promotes continuous open flow.
Low Visibility: In private offices and restrooms which are enclosed it can be observed they are in blue which also indicates low visibility and high isolation.

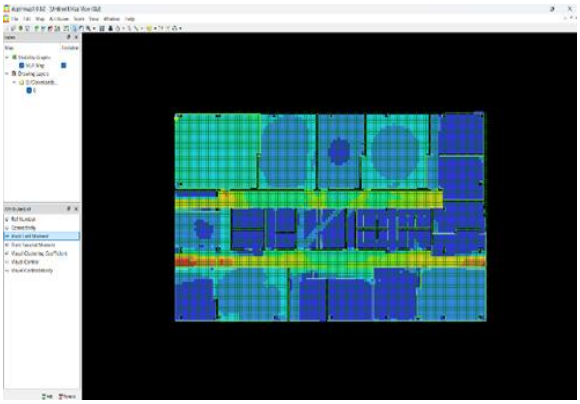

fig: Point First Movement

- Point First Moment Analysis: Point of Initial Analysis:

High in the central corridors (red/yellow) it can be observed strong visual fields and spatial integration.
Blue spaces which are mostly enclosed present low visibility and isolation from the main flow.

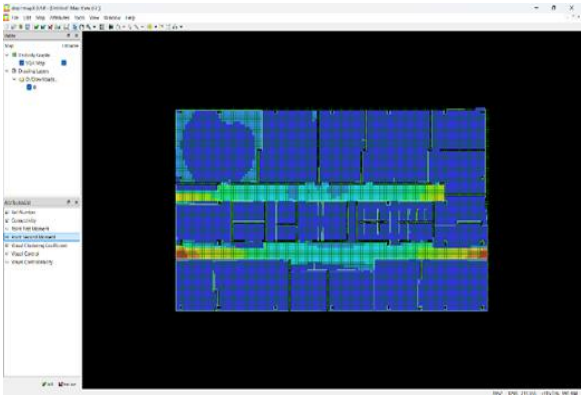

fig: Point second Movement

- Point Second Moment Analysis: Point Central Moment Analysis:

In the central corridors there is a choice of many movement options and flexible navigation, in enclosed rooms however which present themselves as different areas the movement options are few and flexibility is a lesser.
Key Observations: The main corridor is the backbone of connectivity and movement. Enclosed spaces which do provide privacy may at the same time reduce chance of spontaneous collaboration. Easily recognizable movement paths for strong wayfinding.
Conclusion: In the axial plan it can be observed a large central corridor which is the focus and backbone. However, isolated and enclosed spaces are also present, which may hinder collaboration by limiting opportunities for spontaneous interaction.

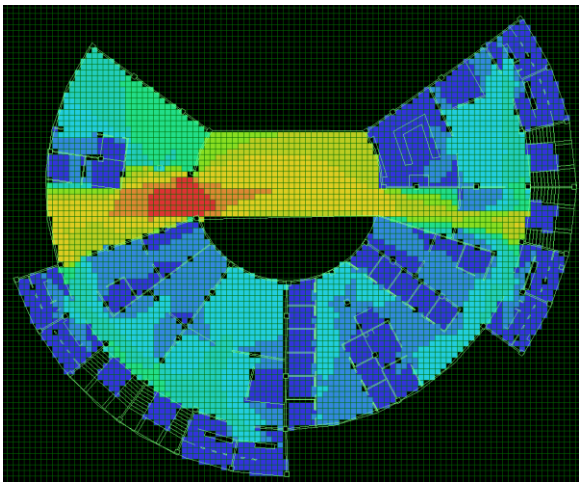

Fig: VGA for radial plan

2.2 Specific Analysis for Radial Plan
Connectivity Analysis: Connectivity Study:
The primary horizontal corridor exhibits the highest degree of connectivity (represented in red and yellow) and functions as the main spine for circulation within the layout. Situated between the central corridor and the radial wings are green-coded spaces, indicating moderate visibility and interaction potential.
Peripheral spaces, depicted in blue, are spatially segregated to support privacy and task-focused activities.

Observations:
Connectivity progressively decreases from the central core toward the outer edges. The radial design, characterized by a strong central focus, simultaneously positions private and task-specific zones along the periphery.

Conclusion:
The radial plan achieves a balance between collaborative and private spatial needs by situating large open zones at the core while allocating the outer edges for more secluded, task-oriented functions. This configuration proves effective for work environments that require both interaction and focused productivity
Connectivity Analysis: Connectome Analysis:
High Connectivity Areas (Red/Yellow): In the main hallways which give view access to many spaces. These hallways also serve as the primary movement routes.

Moderate Connectivity Areas (Green): Transverse regions which branch from the spine, which in turn enable smooth yet secondary movement.
Low Connectivity Areas (Blue): Represent spaces which are private and isolated which in turn gives privacy but at the cost of casual visual connection.

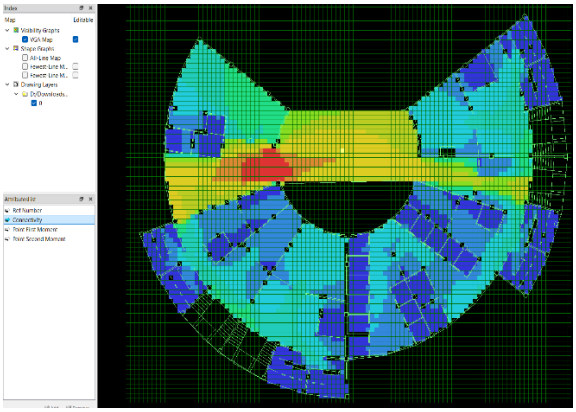

fig: Point First Movement

- Point First Moment Analysis:

What you can see from each point.
High Values (Yellow/Light Green): Central zones provide the greatest visual range which in turn makes navigation easy and intuitive.
Moderate Values (Green/Cyan): Seen in the areas between the core and the peripheral zones.
Low Values (Blue): Enclosed spaces which promote privacy and focused activities.

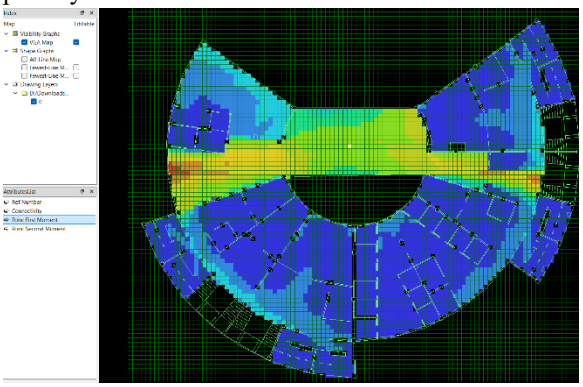

fig: Point First Movement

- Point Second Moment Analysis:

Counts the choices of movement from each point.
Low Directional Bias (Yellow at Center): In the center of the space movement is easy and ambiguity is at a minimum.
Higher Directional Bias (Peripheral Wings): Peripheries have less action which in turn supports more focused task-oriented settings.
Plan-Wise Detailed Analysis

2.3 Axial Plan Analysis:
The heart of the building.
First Moment: High visibility at a distance, low visibility in small spaces.
Second Moment: Strong in the corridors; in isolated areas few.
Key Observations: Main Points:
Axial layout presents a clean hierarchy and easy navigation.
Enclosed spaces which do provide privacy may also reduce chance of spontaneous collaboration.
The layout is of a structured linear form.

2.4 Radial Plan Analysis:
The primary horizontal corridor which is the main artery with radial extensions which go out.
Connectivity: At the peak in the center, diminishing toward the wings.
First Moment: Central areas present wide views; wings focus on privacy which is limited.
Second Moment: The spine facilitates free movement; the wings direct more purposeful circulation.
Key Observations:
The radial design features clearly defined zones, offering excellent wayfinding at the center and increasing levels of privacy toward the periphery. Collaborative functions are concentrated at the core, while spaces intended for private or focused work are situated along the outer edges.
Overall Summary:
Both analyzed plans incorporate a prominent central element that organizes circulation; however, they differ in spatial arrangement strategies.
Axial Plan: Emphasizes a linear, hierarchical structure that guides movement and organization.
Radial Plan: Encourages zoned specialization, which enhances spatial clarity and accommodates a variety of work styles

3. UNDERSTANDING AGENT GRAPH ANALYSIS

Agent Based Analysis of which also goes by the term Agent Graph Analysis model's human movement through a floor plan to present how users usually interact with that space.
Color Coding:
Red and Yellow Lines: High activity level primary circulation paths.
Green Lines: Also known as secondary routes.
Blue Lines: Low traffic private and quiet spaces.
Movement Patterns and Circulation: Flow and Action:
Central Corridors: Act as the primary circulation spaces which connect major functional areas.
Peripheral Areas: Show low activity levels in which quiet task-oriented spaces are supported.
Movement Bottlenecks: In high traffic areas congestion may occur at main intersections or entry points.
Interconnectivity: In large areas travel is easy but you have to seek out which rooms are which.
Design Implications:
For enhancing Access: Improve flow between quiet and active areas in terms of space use. To manage Congestion: Expand corridors and also put in buffer zones during peak time. Encourage Use of Peripheral Spaces, add features that will enliven quiet spaces.
Support Wayfinding: Use primary robust central spines for intuitive movement.

3.1 Plan-Wise Agent Graph Analysis

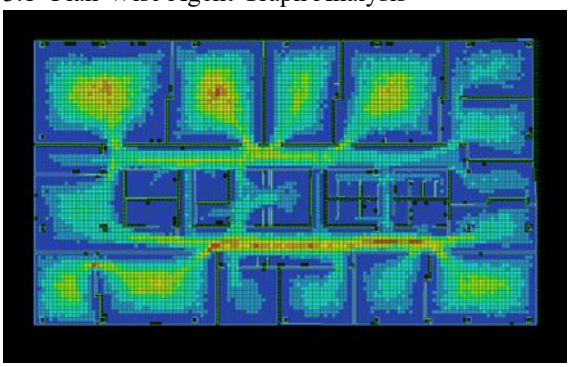

fig: agent graph analysis

- Axial Office Floor Plan:

High Movement Zones: Central corridor and major room entrances.
Medium Movement Zones: Semi-open transition spaces.
Low Movement Zones: Enclosed offices and service areas at the corners.
Key Observations:Central corridors ensure easy access and orientation. Peripheral rooms are isolated both visually and physically. Bottlenecks may occur at major intersections.
Design Recommendations: Introducing auxiliary connections. Widen central paths where possible. Use buffer zones to reduce noise in high-traffic areas.

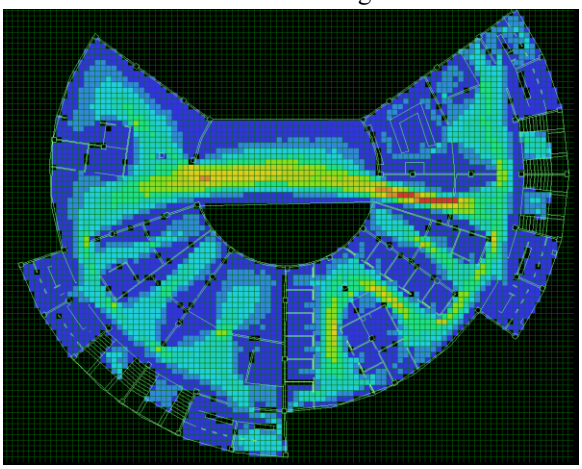

fig: agent graph analysis

- Radial Office Floor Plan:

High Movement Zones: Central corridor and major workspace entry points.
Medium Movement Zones: Shared spaces branching off the spine.
Low Movement Zones: Curved wings hosting private offices.
Key Observations: Clear division between active centers and quieter wings. Some congestion at entry points to radial arms. Movement patterns emphasize zoned privacy and collaboration.
Design Recommendations: Improve transitions at the junctions between spine and wings. Activate peripheral spaces with amenities. Strengthen visual cues for wayfinding along the spine and arms.

4. AXIAL GRAPH ANALYSIS AND ATTRIBUTE SUMMARY

Key Concepts:
Connectivity: How well spaces are visually connected.
Line Length: Measures direct path lengths — longer lines indicate longer visual fields.
Choice: Frequency of space selection for movement.

Entropy: Unpredictability of routes.
Integration: How central or accessible spaces are.
Intensity: How often spaces are used.
Harmonic Mean Depth: Measures spatial isolation.
Mean Depth: Averages the number of steps between spaces.
Node Count: Total number of points analyzed.
Relativized Entropy: Adjusts entropy by available movement options.

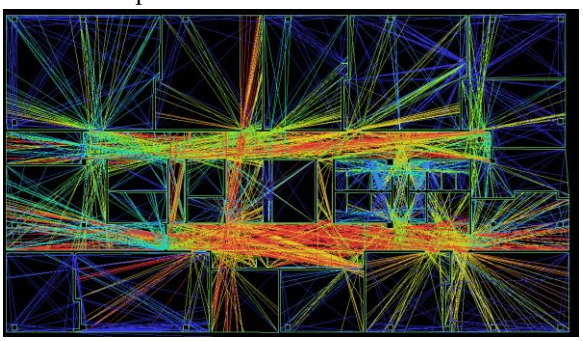

fig: agent graph analysis

4.1 Axial Office Floor Plan – Attribute Summary:
Connectivity: Avg 8.85 (Max 29) — Strong central corridor.
Line Length: Avg 377.08 — Longer sightlines along the spine.
Choice: Avg 159.29 — High movement through core spaces.
Entropy: Avg 1.98 — Moderate spatial complexity.
Integration: Avg 2.27 — Well-integrated central zones.
Intensity: Avg 1.14 — Active movement.
Harmonic Mean Depth: Avg 6.70 — Higher depth in isolated spaces.
Mean Depth: Avg 2.89 — Efficient overall circulation.
Node Count: 85 — Moderate complexity.
Relativised Entropy: Avg 1.81 — Balanced randomness and structure.
General Analysis:
The central spine (likely the main corridor or larger open spaces) appears highly integrated and connected, serving as a major pathway for movement.
Peripheral spaces show higher depth values, indicating they are less integrated into the overall circulation network, making them harder to reach.
The Choice and Integration values suggest that the layout is designed to encourage movement through central areas, but some peripheral spaces may suffer from low visibility and accessibility.
High Entropy and Intensity values in certain zones suggest that these areas are subject to more unpredictable movement, with some parts of the floor plan possibly becoming bottlenecks.
The Harmonic Mean Depth and Mean Depth values indicate some distance inefficiencies in the floor plan, suggesting a possible need for better integration between spaces.

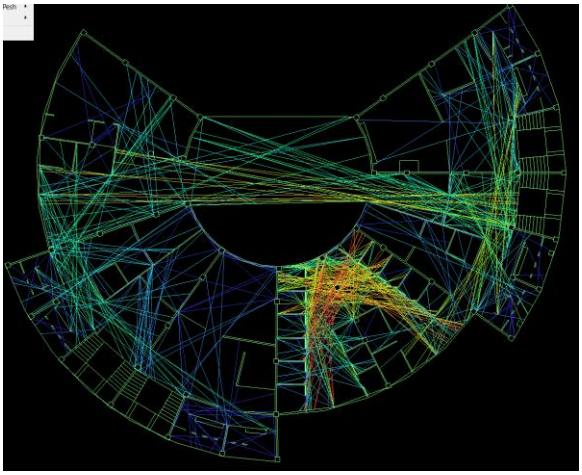

fig: agent graph analysis

4.2 Radial Office Floor Plan – Attribute Summary:
Connectivity: Avg 184.37 — Very strong connectivity at the core.
Line Length: Avg 10.91 — Compact visual fields.
Choice: Avg 8070.31 — Extremely critical movement hubs.
Entropy: Avg 2.29 — Moderate complexity in movement.
Integration: Avg 3.54 — Strong spatial integration at center.
Intensity: Avg 0.897 — Moderate overall movement.
Harmonic Mean Depth: Avg 157.76 — Higher isolation at the periphery.
Mean Depth: Avg 3.64 — Generally efficient circulation.
Node Count: 3050 — Very detailed mapping.
Relativised Entropy: Avg 2.14 — Balanced spatial organization.
The Axial Graph and Attribute Summary analysis reveal that the radial plan layout provides strong centralized movement and spatial integration through its dominant horizontal corridor. However, peripheral areas show reduced accessibility and visual

connection, necessitating thoughtful design interventions such as secondary connections or spatial widening to optimize circulation further. Overall, the plan successfully balances efficient core navigation with private, enclosed working zones, aligning well with the functional goals of a modern office layout.

5. CONCLUSION

- Spatial Dynamics and Movement Patterns:

The study analyzed office floor plans using Visibility Graph Analysis (VGA) and Agent-Based Analysis to understand spatial visibility, connectivity, and user movement patterns.

- Role of Central Corridors:

In both axial and radial plans, central corridors emerged as dominant spines for circulation, ensuring strong connectivity and efficient visual access across spaces.

- Axial Plan Insights:

The axial plan demonstrated a linear and hierarchical organization.

It enabled clear wayfinding but led to higher isolation in private spaces, limiting opportunities for spontaneous collaboration.

- Radial Plan Insights:

The radial plan successfully balanced openness at the center with privacy at the edges.It fostered intuitive navigation and supported a dynamic mix of collaborative and task-focused work environments.

- Agent Graph Observations:

Agent movement patterns showed that central corridors in both plans experienced high traffic and potential bottlenecks at intersections.The radial plan displayed a better distribution of movement intensity compared to the axial plan.

- Spatial Performance Comparison:

The radial layout showed higher connectivity, stronger integration at the core, and a more intuitive zoning of spaces.The axial plan was better suited for formal, structured offices requiring clear directionality and higher degrees of privacy.

- Impact of Spatial Configuration:

Strategic spatial planning—whether through linear clarity (axial) or branched specialization (radial)—was found to directly influence navigation, collaboration, and overall user experience.

- Design Implications:

Thoughtful use of visibility and movement analyses can significantly enhance office design by improving functionality, encouraging interaction, and creating adaptable work environments.

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