Group Coursework Submission Form

Specialist Masters Programme

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1. Data analysis procedure

This analysis aims to enhance the efficiency of Silicon's R&D projects in microprocessor development. The dataset includes information on project outcomes, employee-team relationships, and the knowledge exchange (KE) among employees specialising in microprocessors. We calculated network analysis metrics for each employee within the knowledge exchange network, focusing on node degree, clustering coefficient, connectedness, betweenness centrality, and Burt’s constraint index. These individual metrics were then aggregated at the team level to summarise team characteristics, making it possible to compare subgraphs (teams).

To identify the business problem for the objective function of maximising project success. Initially, we compared the distribution of individual betweenness centrality of nodes in the KE network with the equivalent distribution from 500 randomly generated networks, each with the same number of nodes and edges. This comparison helps determine whether the KE network exhibits characteristics of a "small world network." If it does, the impact of "Bridging Ties" on project efficiency is an intriguing avenue for further analysis. "Bridging Ties" enhance bridging social capital, enabling teams with these ties to access unique, non-redundant information or to receive information more rapidly.

We compared teams based on their members' positions within the knowledge exchange network and examined each group’s density measures to gain a more accurate understanding of their dynamics. We started by calculating the teams' averages (mean) for each network analysis variable to provide a concise summary of each team. However, to gain a more robust understanding, we extended our analysis to include additional measures of dispersion, such as interquartile range (IQR), and range. Relying solely on the mean could have led to misleading insights, as it might not fully capture the distribution of employees' KE positions within a team. For example, using only the mean for betweenness centrality would overlook differences in members' KE position: a team with uniform centrality values would appear similar to a team with varied central and bridging positions.

To conduct the statistical analysis, we selected key variables that reflect a project's efficiency: success, duration, and novelty. Technical success was included to determine whether a project was completed or failed. Duration was chosen to evaluate economic efficiency, as longer projects delay other assignments. Novelty was also considered, as stagnation in innovation can negatively impact a company's long-term success. These variables were necessary to identify factors influencing project outcomes and guide recommendations for improving efficiency.

For statistical analysis, we created correlation matrices including variables of betweenness centrality, node degree, Burt’s constraint index, clustering coefficient, and connectedness, all summarised at the team level, as well as a team’s project success, duration, and novelty. The goal was to gain insight into which variables influence a project's efficiency, as represented by success, duration, and novelty. We compared the matrices of different team summarisation methods. All matrices showed mostly the same trend, so we proceeded with the matrix that exhibited the highest correlation values.

Following that, we applied network theory from the social capital theories to conceptualize the framework and interpret the network data to offer valuable business recommendations based on the key influences on project outcomes.

2. Results

The network has 543 vertices representing basic employees; the edges are equal to 3,258 to indicate the relationship between nodes. In this study, we look at the density and bridging ties matrics to understand structure, connectivity, and relationship patterns within the knowledge exchange network that influence the project success rate.

1. Knowledge Exchange Network Structure and Small World Properties

Silicon's R&D knowledge exchange network demonstrates clear small-world characteristics through two key comparisons with random Erdős–Rényi graphs:

Our network shows higher betweenness centrality distribution skewness (1.442) compared to random networks (1.017), indicating a more organised and efficient path structure. This higher skewness means our network has strategically positioned bridge nodes that create efficient paths for knowledge flow between different parts of the R&D department, unlike the random networks' more uniform distribution of paths. The network shows remarkably higher clustering (0.5836) compared to random networks (0.0221), with a ratio of 26.39x. This indicates that Silicon's R&D employees form dense local collaboration groups far more than would occur by chance. These tight-knit clusters enable efficient local knowledge sharing and technical collaboration. These properties create an ideal knowledge-sharing structure: dense local clusters connected by strategic bridges.

2. Team-Level Network Analysis and Impact on Project Outcomes

The analysis of network characteristic metrics illustrates how network structures impact project outcomes within Silicon's R&D department. Analysing a correlation matrix revealed that team efficiency - measured by success, novelty, and project duration - correlates with three key metrics: betweenness centrality, constraint, and clustering coefficients.

Teams with relatively high average clustering coefficients (ranging from 0.471 to 0.671) show a positive correlation with technical success (0.412) and a strong negative correlation with project duration (-0.635). This indicates that teams with dense internal connections are more likely to complete projects successfully and do so more quickly. The high correlation between clustering and constraint (0.976) further reinforces that tightly-knit teams with redundant connections perform better in technical execution.

However, the data reveals interesting trade-offs in team structure. Teams with high betweenness centrality show a positive correlation with both project novelty (0.422) and duration (0.644) but a negative correlation with technical success (-0.460). This suggests that while teams with strong bridging ties generate more innovative solutions, they take longer to complete projects and face higher risks of technical failure. The negative correlation between betweenness centrality and constraint (-0.934) indicates that these metrics represent opposing team structures - either focused on deep internal collaboration or broad knowledge access.

Project duration shows significant relationships with network metrics, negatively correlating with both clustering (-0.635) and constraint (-0.640) while positively correlating with betweenness centrality (0.644). This pattern suggests that project timelines are strongly influenced by team structure - tightly connected teams work faster, while teams with more bridging ties require more time but potentially deliver more innovative results.

Project novelty shows moderate negative correlations with both clustering (-0.412) and constraint (-0.406), while positively correlating with betweenness centrality (0.422). This indicates that innovation benefits from diverse knowledge access rather than dense internal connections. The moderate strength of these correlations suggests that while network structure influences innovation, other factors also play important roles.

Technical success shows strong positive correlations with both clustering (0.412) and constraint (0.421), while negatively correlating with betweenness centrality (-0.460). This clear pattern indicates that dense, internally focused team structures are more reliable for achieving technical objectives. The negative correlation between technical success and project duration (-0.312) further suggests that longer projects face increased risks of technical challenges.

These relationships provide Silicon's R&D management with clear guidance: team structure should align with project objectives. Projects requiring reliable technical execution benefit from high clustering and constraint, while innovation-focused projects need higher betweenness centrality despite the associated time and risk trade-offs.

3. Business recommendations

Based on our network analysis, here are strategic recommendations for improving Silicons's R&D efficiency:

Silicon's R&D department should adopt differentiated team formation strategies based on clear project objectives and a dynamic evolution approach to maintain efficiency and innovation potential. This comprehensive strategy addresses the dual challenge of maintaining reliable project execution while fostering breakthrough innovations in microprocessor development.

1. Form a Team Based on Project Objective

For projects focused on reliable execution and incremental improvements, the R&D head should prioritise forming tightly-knit teams where engineers and technicians have established working relationships. These teams should comprise members who have previously demonstrated successful collaboration and share common technical backgrounds in microprocessor development. When team members maintain direct working relationships with regular interaction patterns, they complete projects more quickly and achieve higher technical success rates. This approach proves particularly effective for projects involving standard microprocessor improvements where reliability and efficiency are paramount. The tightly connected team structure enables quick problem-solving and efficient knowledge sharing, essential for meeting technical objectives within the standard three-month project timeline.

The positive correlation between clustering coefficients and project success suggests that teams with low connectivity can benefit from increases in cohesion. Encouraging practices that strengthen internal ties, such as team-building exercises, shared problem-solving sessions, promote open communication through frequent meetings. Strong internal team ties will foster trust, reliability, and efficient communication.

However, team composition requires a distinctly different approach for projects aimed at breakthrough innovations. These teams should be structured to include a mix of specialists from different technical domains, complemented by experienced engineers who regularly work across multiple technical areas. While this diverse composition typically requires longer project timelines, it creates an environment conducive to novel solutions. For such innovation-focused projects, the R&D head should consider extending durations from the standard three months to 4-5 months, acknowledging that diverse perspectives and new collaboration patterns require additional time to yield results. The strategic value of breakthrough improvements in microprocessor technology justifies the trade-off between extended duration and increased innovation potential.

2. Implement Dynamic Core-and-Rotate Model For Balanced Innovation

To optimise both team structures, Silicon should implement a dynamic core-and-rotate model. When teams demonstrate strong technical success and efficient project completion, they should remain largely intact for subsequent projects. This continuity allows teams to leverage their established working relationships and shared understanding of technical challenges. However, to prevent stagnation and encourage innovation, the R&D head should systematically rotate one or two positions within these successful teams between projects approximately every three months to align with standard project duration.

Engineers who demonstrate strong capabilities in working across different technical domains and project teams should fill these rotating positions. For example, a successful team working on microprocessor optimisation might maintain its core members who understand specific technical challenges while rotating in engineers with experience in emerging semiconductor technologies or alternative architectural approaches. This approach maintains the benefits of team cohesion while systematically introducing new perspectives and technical knowledge into established teams.

3. Establish Criteria For Monitoring Performance And Adaptation

The R&D head should establish clear criteria for selecting both core team members and rotation candidates. Core team members should demonstrate strong collaborative capabilities and deep technical expertise in specific areas of microprocessor development (High Clustering/High Constraint). Rotation candidates should show proficiency in working across different technical domains and the ability to integrate into established teams while contributing fresh perspectives quickly (High Betweenness/Low Constraint).

Success in implementing these recommendations requires careful monitoring of team performance metrics. The R&D head should track both technical success rates and innovation outcomes, ensuring that teams maintain their execution efficiency while improving their capacity for generating novel solutions. This monitoring should inform future team formation decisions and adjustments to the rotation schedule.

This strategic approach to team management enables Silicon to optimise its project-based R&D structure for both immediate technical needs and long-term innovation goals in microprocessor development. By carefully balancing team stability with structured knowledge exchange through strategic rotation, Silicon can maintain high technical success rates while systematically building its capacity for breakthrough innovations. The key lies in recognising that different project objectives require different team structures and implementing a flexible yet systematic approach to team formation and evolution.

Resources:

1. Burt, R.S. (1992). Structural holes: the social structure of competition. Cambridge, Mass. Harvard Univ. Press.
2. Burt, R.S. (2007). Brokerage and closure: an introduction to social capital. Oxford: Oxford University Press.
3. Newman, M. (2018). Networks. OUP Oxford.