Network Analysis

A ROLE-PLAYING GAME SOCIAL NETWORK ANALYSIS

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Abstract

The paper unfolds the "Fallout: New Vegas" videogame events with a social network analysis approach thanks to five different scenarios, revealing nodes relationships and their differences. In particular, the nodes correspond to the game characters and the edges represent their bonds. Network and nodes measures such as centrality, nodes positions, density, modularity, and components are applied to study every scenario situation. Finally, there is an analysis about which of the four endings might be the most balanced one and why.

Context

Fallout: New Vegas is a 2010 action role-playing game in which the player can interact with more than 300 characters and a variety of major and minor factions. All the Fallout series is set in a retro-futuristic world[1] destroyed by a global nuclear event. The protagonist is a courier who roams post-apocalyptic Nevada, gripped by the shadow of an imminent war for control of New Vegas. The game does not have a single ending, as the player faces numerous choices to determine the fate of the Mojave Wasteland. Every faction could potentially take over and, among the possible endings, the player could also decide not to trust anyone, thus seizing power of the whole area.

Figure 1. A cutscene from one of the many New Vegas endings.

The general field of study is Role-Playing Games, and the specific application Role-Playing Games Studies.

Major factions: the Courier, Mr. House, NCR, Caesar's Legion

"Truth is, the game was rigged from the start." - Benny

The plot revolves around a courier (the playable character) who is hired in order to recover a certain artifact called The Platinum Chip on behalf of the mysterious Mr. House. The latter is in reality a very rich man who managed to connect his body to a computer system before the war thus surviving for 200 years barricaded inside his impenetrable casino: the Lucky 38, guarded by robots of his own invention called Securitrons. During the war he used his genius and wealth to ensure that no missiles would strike the city and, as time passed, he designated various tribes of survivors (the Omertas, Chairmen, and White Glove Society) as the heads of the other casinos in the city creating a sort of ruling class from which his main assistant Benny is from.

Over the years the city of New Vegas and the surrounding Mojave Desert became a free zone and a very prominent caravan centre but, the discovery of Hoover Dam on the Colorado River soon sparked the expansionist aims of two political entities: the New California Republic and the Legion.

Originated in the west coast as a federation of five states, the NCR is a democratic state in the style of the ancient pre-war governments: political enfranchisement, rule of law, a reasonable degree of physical security, and a standard of living better than mere subsistence are daily realities for its growing population. Nevertheless, it manifests some crucial and serious problems such as rampant corruption, a devastating economic inflation, and the need to adopt an imperialist foreign policy for

[1] The actual look and mood of the Fallout series is referred as the *future of the fifties* by the Art Director: the setting and artwork are influenced by the post-war culture of 1950s United States.

the recovery of resources. Embroiling its army in a morally corrosive imperialist project, the NCR managed to conquest Hoover Dam and sign the Treaty of New Vegas with Mr. House defining the balance of power in the area to the detriment of the Legion.

The Legion is a big ensemble of tribes, which lost in the First Battle of Hoover Dam. Currently, they are reorganizing themselves on the other side of Colorado River in view of the next battle. Established in the east under the authority of the charismatic leader Caesar, the Legion consist of a slave warrior society: people of conquered tribes are stripped of their tribal identities and turned into slaves or ruthless legionaries. Their troops are well-organized, moving and attacking in large packs, and deliberately committing atrocities to terrorize those who dare to oppose them, but at the same time they guarantee order and security in the internal territories within their borders. In Vegas, Caesar, the self-styled son of Mars, found his Rome.

In 2281, years after the First Battle of Hoover Dam the stability of the region is threatened by the shadow of a new war. Even the most marginal factions are called to take their places in the complicated political scenario that stands out on the Mojave at the dawn of the conflict. It is at this historic moment that the Courier is captured, shot, and buried by Benny just outside the city. The Chairmen's leader, Benny, dominated by his own greed and ambition betrayed Mr. House and stole the Platinum Chip, the key to activating an army of Securitrons buried beneath the city. Benny wants to use them to take over New Vegas with the help of an artificial intelligence called Yes Man.

Problem and Motivation

By performing a *What-if* analysis on different ending scenarios of the RPG *Fallout: New Vegas* I will describe what are the main changes in the characters' network and study its evolution under certain circumstances. Hopefully, this kind of study could help understanding how relationships with NPCs and alliances with different factions could radically change or disappear, and which ethically correct or incorrect or neutral paths a *Fallout: New Vegas* player could choose.

Datasets

Data are first retrieved in the Fallout New Vegas official wiki and in the official game guide[2], and subsequently used to build the starting network on Lucidchart.

It includes the main characters of the game (nodes), their relation status (presence or absence of edges) and – in case of presence – additional info about alliance, neutrality, or hostility. The network is then saved both in .png and .csv formats in order to be included in the report as a first useful visualisation (as in this case) and used in Gephi for the analysis.

STARTING SCENARIO: THE CONTEXT

The first act of the game consists of travelling the Mojave in search of Benny, who will be found in his casino in the Strip. Upon reaching New Vegas, the Courier has already had the opportunity to deepen relations with the numerous factions distributed throughout the territory and can begin to lay the groundwork for what will be the ending scenarios.

The previously described moment in the game is in our analysis what is referred to as the *starting* scenario, set when the Courier has already met all the major and minor factions and understood what kind of bonds exist between the NPCs, but still not interfered with them.

Despite mentioning him, the Courier was purposely left outside of the analysis as he interacts with the whole game characters, thus his node would have been connected to every other node in a

[2] Hodgson, David. *Fallout New Vegas: Prima Official Game Guide*, pdf version.

hypothetical network, leading it to become an ego-network, definitely not appropriate in this particular research. His role in the Independent New Vegas scenario was taken by Yes man: the AI subordinate to Benny at the very beginning of the game who later could side the protagonist.

Validity and Reliability

About validity, I included in this study 56 NPCs, specifically selected on their importance on the outcomes of the game. Hence, the model of my dataset does not represent the 100% of the game lore. For example, NCR or Caesar's soldiers without a name, children or NPCs who do not have a real impact in the main quests are deliberately left out of the social network.

The social network built for the starting scenario is consistent with the *Fallout: New Vegas* lore, as I gather all the information on its official wiki webpage and on the official game guide. The links between characters are then checked either on the wiki and through a gameplay session.

Measures

For the purposes of the study, the following nodes and network measures are applied:

- Degree centrality – to find out about the most connected nodes in the game network
- Eigenvector Centrality – to measure the level of influence of a node within a network, thus learning about the most influential game characters
- Betweenness and closeness – to reveal characters' "positions" in the network in different scenarios. In particular:
    - Betweenness – for finding the individuals who influence the flow around a system
    - Closeness centrality – for finding the individuals who are best placed to influence the entire network most quickly
- Ordinal scales – to understand whether and how much "positive" and "negative" relationships change
- Group of nodes (connected components) – to describe how connected the networks are or are not
- Modularity – to visualise the different factions
- Cohesion (density) – to study how connected the networks are
- Kind of network: small world vs scale-free network – to define the type of network

Results

And so the Courier, who had cheated death in the cemetery outside Goodsprings, cheated death once again, and the Mojave Wasteland was forever changed.

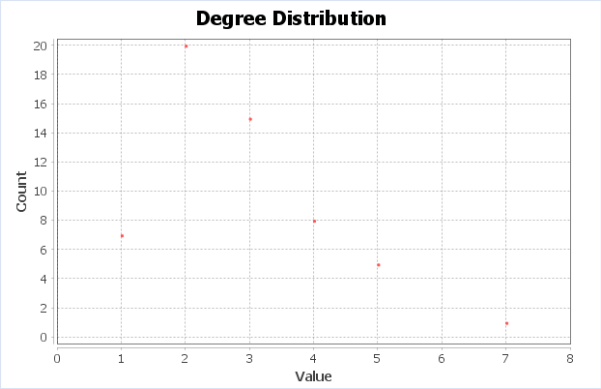
This chapter includes the analysis of the results for every measure used in the five scenarios. First, it will be defined whether these networks are small-world or scale-free ones, next there follows a dedicated chapter for every situation, from the starting network to the various game-ending scenarios: here data evaluations are accompanied by lore explanations.

KIND OF NETWORK

A characteristic of scale-free networks is the peculiar ratio between clustering coefficient and degree of nodes. *Table 1*, shows that the degree is inversely proportional to the clustering coefficient, thus suggesting that the reference network (starting scenario) is a scale-free network. In this table, nodes with clustering coefficient equal to 0,0 were left outside of the analysis since considered not influent. The missing nodes in *Table 1* had mostly a degree equal to 2 or 1.

LABEL	DEGREE	CLUSTERING	LABEL	DEGREE	CLUSTERING
Mr. House	7	0,142857	*Julie Farkas*	3	0,333333
Caesar	5	0,3	*Arcade Gannon*	3	0,333333
Benny	5	0,2	*Papa Khan*	3	0,333333
President Kimball	5	0,2	*Regis*	3	0,333333
Colonel Moore	5	0,2	*Tabitha*	3	0,333333
Vulpes Inculta	5	0,2	*Doc Henry*	3	0,333333
Big Sal	4	0,5	*Karl*	3	0,333333
Nero	4	0,5	*Ambassador Crocker*	3	0,333333
Emily Ortal	4	0,333333	*Major Kieran*	3	0,333333
Marcus	4	0,333333	*Diane*	3	0
Pacer	4	0,166667	*Elder McNamara*	3	0
Colonel Hsu	4	0,166667	*Trudy*	3	0
Alice McLafferty	4	0	*Major Dhatri*	3	0
Gloria Van Graff	4	0	*Yes man*	2	1
Lily	3	0,666667	*Legate Lanius*	2	1
General Lee Oliver	3	0,666667	*Cachino*	2	1

Table 1. Degree and clustering of some nodes in the starting scenario. The clustering coefficient is decreasing while the degree value increases.



A network can be defined "scale-free" when its degree distribution follows a power law. The average degree of the starting scenario network is 2,789 and *Figure 2* describes how most of the nodes in the network have a low degree: the slope here recalls the typical power law graph. Even if it is a small network, the degree distribution confirms it is scale-free.

Figure 2. Average degree distribution of the Starting scenario calculated on Gephi.

STARTING SCENARIO: AIN'T THAT A KICK IN THE HEAD

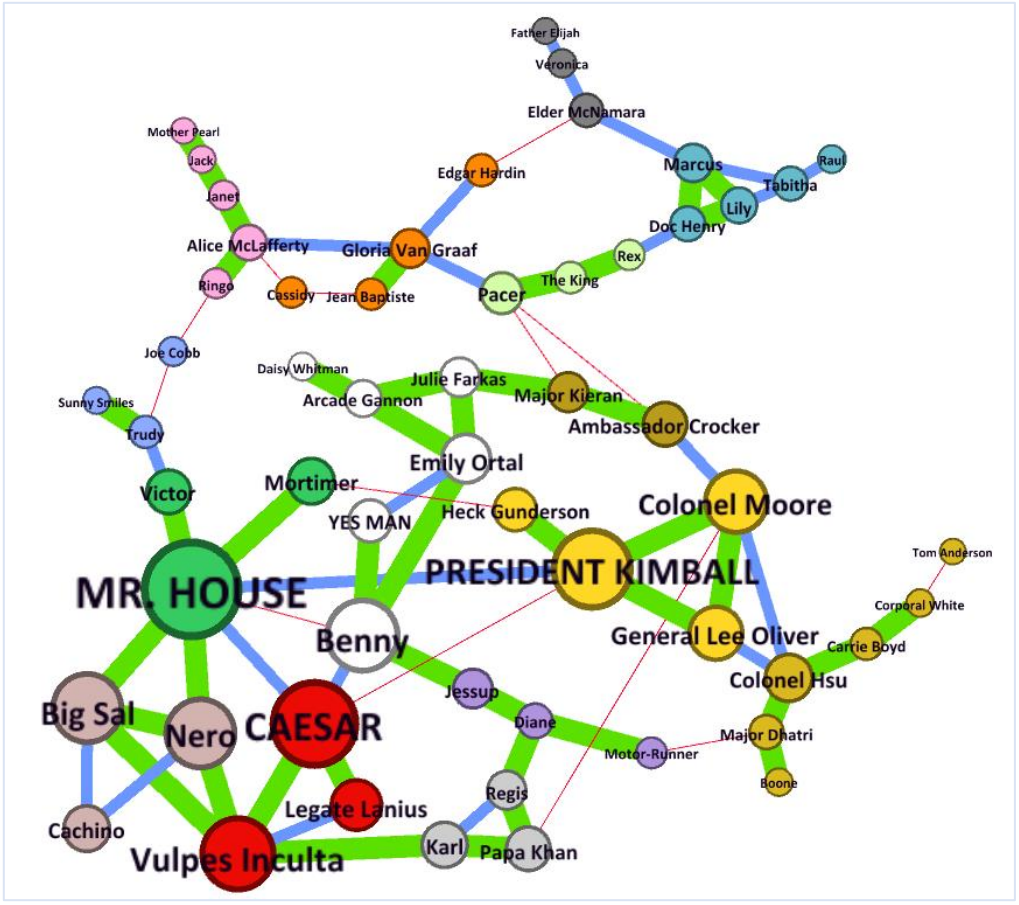


Figure 3. Starting network: nodes, communities, and alliances.

Gephi **Modularity** function (with resolution value 0.3 to recognise smaller communities) was able to identify 14 different communities. This subdivision is quite accurate, but still not perfect. The names in capital letters in *Figure 3* represent the fundamental characters, the leaders of the main factions in the game. The weighted undirected edges describe the relationships between the nodes: green for alliance, blue for neutrality and red for hostility. The factions recognised are:

- Mr. House, Victor, White Glove Society (Mortimer)
- The Kings
- The Chairmen (Benny), Yes Man, Followers of the Apocalypse, Enclave Remnants (D. Withman)
- New California Republic, political-military leaders
- New California Republic at Camp McCarran
- New California Republic at New Vegas
- Caesar's Legion
- Van Graff, Cassidy, Brotherhood of Steel (E. Hardin)
- Brotherhood of Steel
- Great Khans, Caesar's Legion (Karl)
- Omertas
- Crimson Caravan Company, Boomers (Jack, Mother Pearl)
- Fiends (Motor-Runner), Great Khan (Jessup, Diane)
- Jacobstown, Black Mountain

In particular, Mr. House and the White Glove Society (a minor faction) are mistakenly in the same community; Benny, who represents the Chairmen alone, is wrongly joined to other minor factions, such as the Followers of the Apocalypse and the Enclave Remnants. Yes man the robot in this scenario is correctly bonded to Benny, since it was programmed to follow his orders; the NCR is fragmented while it should be a single large community; the same happens to the Brotherhood of Steel and Caesar's Legion, where one member each, respectively Edgar Harding and Karl, is not recognised in his real faction. This is probably due to the edges' weights and the degree (E. Hardin's hostility relation with the member of the Brotherhood and Karl bonds with Regis and Papa Khan).[3] Even if the Modularity function split the NCR in three different subgroups, in the following analysis it will be counted as one faction.

In *Figure 3*, the most influential nodes (the bigger ones) are calculated through **Eigenvector Centrality** and correctly mirror the in-game situation. *Table 3* (page 18) shows that, according to Eigenvector Centrality, the most influential nodes in the Starting scenario, are:

1. Mr. House
2. Caesar
3. President Kimball
4. Vulpes Inculta
5. Benny
6. Big Sal
7. Nero
8. Colonel Moore
9. General Lee Oliver
10. Legate Lanius

[3] For a complete overview of the *Fallout: New Vegas* factions: https://fallout.fandom.com/wiki/Fallout:_New_Vegas_factions

The top 10 nodes according to the Degree Centrality measure[4] vary. We find Colonel Moore in 6th position, followed by Big Sal, Nero, Emily Ortal and Colonel Hsu. Since Emily Ortal and Colonel Hsu are not leaders of any major faction in New Vegas and Degree Centrality measurement totally exclude other important NCR characters from the top 10 list, the Eigenvector Centrality is considered a far more accurate centrality measure to understand what the most influential characters in the graph are. Also, in this study the Eigenvector is not biased, as the network of every scenario is undirected, preventing the zero-trailing problem.

Betweenness centrality reveals that the most traversed node is the one labelled "Pacer" (591,75), who links the Kings, the Van Graff's and NCR. He is the King's second assistant, a prominent personality in New Vegas' Freeside. He has antagonised many people there: as it is noticeable in *Figure 3*, "hostile" edges link him with Ambassador Crocker and Major. Other central nodes for what concerns Betweenness are NCR's Colonel Moore (550,5) and the manager Gloria Van Graff (479,25). Colonel Cassandra Moore has a crucial role in linking different NCR departments and she has a direct hatred edge with the Great Khans' leader. On the other side, Gloria is responsible of connecting the almost isolated Brotherhood of Steel to the rest of the network, also she bridges the Crimson Caravan Company to the Kings.

Data about **Closeness centrality** are very similar to each other. For example, while Betweenness centrality values in this scenario range between 591 – 0, Closeness centrality values range between 0,272277 - 0,122494, thus preventing the localisation of a really central node, the closest to every other one[5]. Therefore, the highest Closeness centrality values reported here are not the top three values of *Table 3*, whether the highest values in each individual cluster/faction in the graph. The NCR node which stands out for its highest Closeness is Colonel Moore (0,27), followed by a King member, Pacer (0,26), and the leader of Van Graff's, Gloria Van Graff (0,24). Other central nodes are Mr. House (0,24), Caesar (0,23), Julie Farkas (0,22) and Papa Khan (0,22). The latter are two representants of minor factions, respectively the Followers of the Apocalypse and the Great Khans. At any rate, *Table 3* shows that the actual highest values are assumed by many NCR members (Moore, Crocker, Kimball, Kieran), testifying how central they are as for the other nodes to move around the network in the most efficient way. From the lore point of view, in the Starting scenario one could notice the NCR in fact managed to create a strong social network within the Mojave, with various Camp sites around the area.

Table 2 represents the nodes and edges situation in each scenario. Additional information about hostilities, alliances, network density and components give us a first idea on how different these scenarios are.

NETWORK	NODES	EDGES	HOSTILE EDGES	ALLY EDGES	DENSITY	COMPONENTS
Starting	56	78	13	43	0,051	1
Caesar	38	34	1	23	0,048	9
Independent	47	58	13	27	0,054	1
Mr. House	50	62	9	33	0,051	3
NCR	41	48	7	24	0,059	1

Table 2. Networks features.

[4] See Table 3 at page 14.

[5] «Closeness centrality can help find good *broadcasters*, but in a highly connected network, you will often find all nodes have a similar score. What may be more useful is using Closeness to find influencers in a single cluster.» from https://cambridge-intelligence.com/keylines-faqs-social-network-analysis/.

About the number of nodes and connections, the starting network is rightly the most populated, with 56 nodes and 78 edges; the least connected network is Caesar's one, with 34 edges, and it is also the scenario where the number of nodes is lower. The most connected ending network, considering the ending scenarios, is Mr. House's one, with 62 edges and 50 nodes. Additionally, the number of alliances is high (33 ally edges), while the hostile bonds quite low (9). The smallest ratio "hostilities/alliances" is to be found in Caesar's network and, not so surprisingly, this scenario only includes one hostility bond: this is because Caesar exterminated everyone with whom he had some resentment, also explaining the low number of nodes. A similar reasoning applies to the NCR network.

For what concerns the density of these networks, the first place goes to NCR, followed by Independent New Vegas. Density provides a value of how dense a graph is in terms of edges connectivity and measures how close it is to a complete network (density = 1). In other terms, density tells how efficient the relational exchange between the various elements of the network itself is or, otherwise, low density values underline that the elements of the graph do not communicate with each other. Again, the Caesar's network stands out, with a density of 0,048, the lowest one. It is interesting to notice how the density of the other factions' networks (except the already mentioned Caesar's Legion) is always higher than the Starting scenario density – except for the Mr. House case - demonstrating how the cohesion between characters rises.

Regarding the connected components, almost every network is made of a single one apart from the House and the Legion's ones. In the latter, the number of components is 9 and that is due to the already mentioned Caesar's tribes' violence. More detailed analysis together with game lore will come in the dedicated chapters.

CAESAR'S LEGION SCENARIO: VENI, VIDI, VICI!

Caesar entered The Strip as though it was his Triumph. The Legion pushed the NCR out of New Vegas entirely, driving them back to the Mojave Outpost. The Legion occupied all major locations, enslaving much of the population and peacefully lording over the rest. Under the Legion's banner, civilization - unforgiving as it was - finally came to the Mojave Wasteland.

The most striking data of this scenario is the very low number of nodes and edges (38 nodes and 34 edges), the lowest between all endings. To these values follow the lowest degree of density and the highest number of components (9). This is doubtless the most violent scenario in which 18 nodes are obliterated from the beginning: the extreme violence of the Legion warriors is accompanied by the dedication to forcibly eradicate any form of non-compliance and discord.

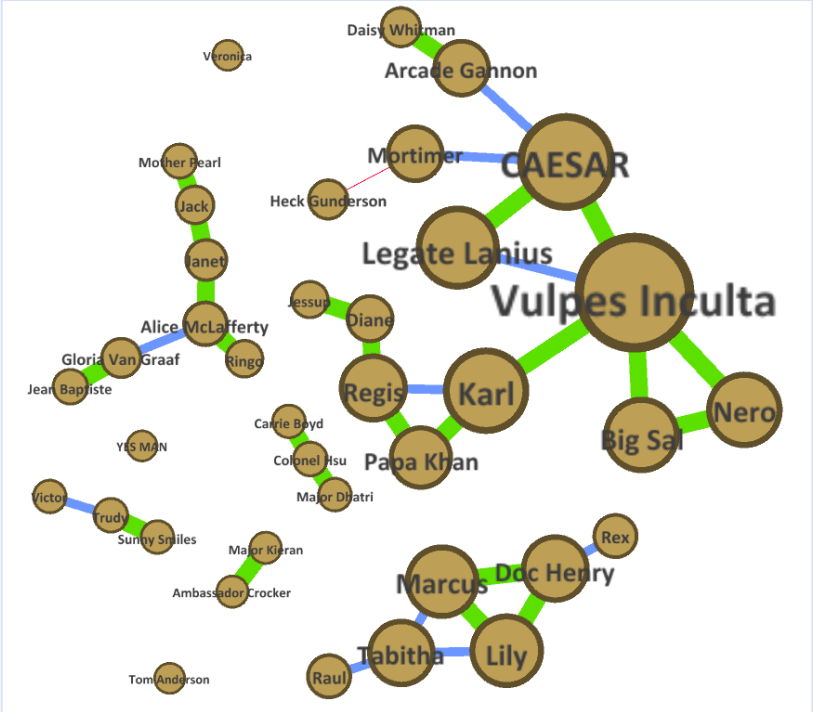


Figure 4. Aftermaths of the Legion's victory in the second battle of Hoover dam.

In this way order is granted (68% of ally edges of the total, highest value) by eliminating

almost all hostile edges (1 remains) and generating many components and a low density that reflects the social and cultural shock of the establishment of the tribal political order of the Legion in the Mojave and the consequent disintegration of the previous socio-political balance.

The **Eigenvector centrality** results show that the most influential character in this scenario is Vulpes Inculta (1), and he comes even before his leader Caesar (0,74) because of the relationships he has with the Omertas (it is the only node connected to Big Sal and Nero) and Karl (0,61 - third most influential node), who links the Caesar's Legion to the Great Khans faction.

The measure of **Betweenness centrality** in this case does not tell us something useful, since the scenario situation is highly fragmented. In the biggest component, the one including Caesar's allies or subordinates, the characters which function as interfaces are: Vulpes Inculta (56), who holds relationships with the Omertas, Caesar himself and Karl, Legion's frumentarius sent to the Khans to confer with them; Caesar, who enslaved Arcade Gannon of the Followers of the Apocalypse as his personal doctor and still has a neutral relation with the cannibal leader of the White Glove Society[6]; Karl, who serves as boundary with the Great Khans. In the second biggest component, Alice McLafferty is an important node (11) as she ties the Boomers and the Van Graff's. Little can be said about Jacobstown and Black Mountain situation: isolated from the others, the slight emphasis for what concerns betweenness goes to Tabitha (4) and Doc Henry (4), characters who connect the outer nodes (Raul and Rex) to their very small community. The other betweenness centrality values are negligible.

An accurate study about **Closeness centrality** values in this scenario would be pointless since the network is too split. Anyway, one could observe that the highest values belong to the smallest components (the components formed by two or three nodes) - Crocker (1) and Kieran (1), Colonel Hsu (1), Trudy (1) - as it is faster for these nodes to reach the other ones. In the most relevant groups of nodes (Caesar's subordinates and, on the other side, Boomers, and merchant's companies), the major values are assumed by Alice McLafferty (0,6) and Janet (0,54) and by Vulpes Inculta (0,5) and Caesar (0,44), situation which resembles to the previous Betweenness centrality analysis.

Independent New Vegas scenario: Wild Card

> *The Courier, with the aid of Yes Man, drove both the Legion and the NCR from Hoover Dam, securing New Vegas' independence from both factions. With Mr. House out of the picture, part of the Securitron army was diverted to The Strip to keep order. Any chaos on the streets was ended, quickly. Chaos became uncertainty, then acceptance, with minimal loss of life. New Vegas assumed its position as an independent power in the Mojave.*

The most prominent node in this network considering the **EigenCentrality** results is the one labelled Yes man (1), as this game ending discloses. Also Arcade Gannon and Emily Ortal have high values (0,76 and 0,65). During the gameplay, if the player decides to take Arcade as a companion and talk with him, they will soon find out that this character is the most favourable to an Independent New Vegas: «The only way to ensure relative safety and independence for the people of New Vegas is to prevent others from taking control of the region. […] That means no NCR, no Mr. House, and no Legion.»[7].

This is the second ending scenario for number of nodes and edges (47 and 58), indicating low number of deaths and strong relationships between the characters. Concerning the kind of bonds, Independent New Vegas boasts 27 alliances and 13 hostilities. The latter may seem a huge value if compared to the other endings hostilities, but it underlines how here the number of deaths is

[6] More information here: https://fallout.fandom.com/wiki/White_Glove_Society.

[7] All of Arcade's lines here: https://fallout-archive.fandom.com/wiki/Arcade_Gannon%27s_dialogue.

drastically lower than in Caesar's and NCR scenarios, where the characters hostile to the factions were eliminated. The density of 0,054 testifies how largely connected the network is.

According to the **Betweenness centrality** measure, the top five nodes which serve as liaisons inside the Independent ending are:

- Yes man (381)
- Elder McNamara (322)
- Alice McLafferty (287)
- Colonel Moore (280)
- Colonel Hsu (272)

Yes man is the hub of the whole graph, and it connects the main factions, thanks to the highest degree of the network (7). Another important position is the one of Elder McNamara, who is linked to NCR's Colonel Moore, Edgar Hardin, and Marcus from Jacobstown. Alice McLafferty on the other hand is four nodes away from Yes man and connects Goodsprings residents and the Van Graffs' to the rest of the graph.

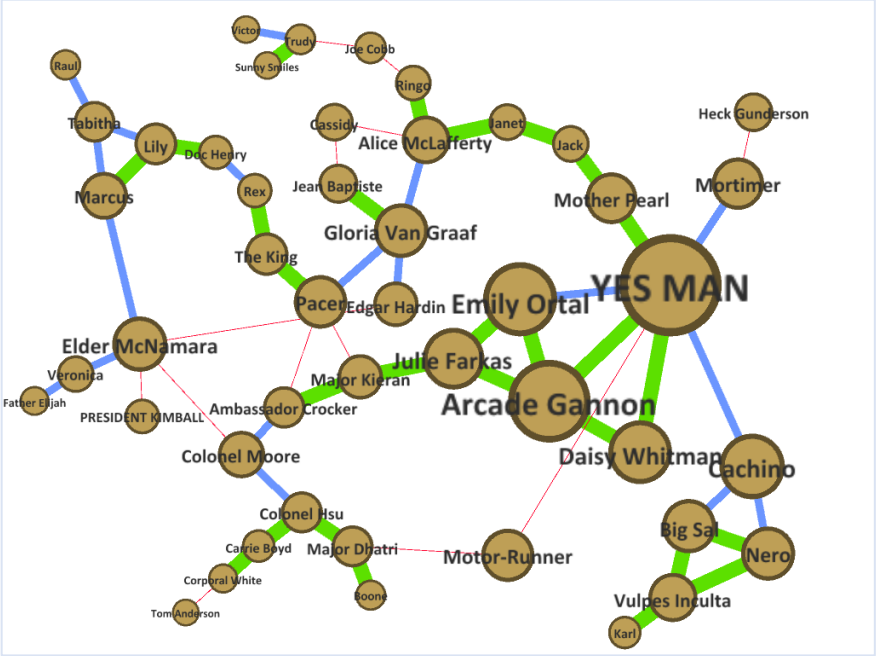


Figure 5. Independent New Vegas network.

Being a highly connected graph, **Closeness centrality** is once again a challenging measure to analyse. In this case, the preliminary Gephi visualisation showed no node standing out for centrality, not even after focusing on individual communities. Looking at the numerical results it was clear that this function is not telling something useful about central nodes: the ten highest values are all around 0,25 – 0,23 while, for example, in the Starting scenario the Closeness for the top ten values was between 0,27 - 0,22. What is does tell is that characters in this scenario are highly connected - hence close to each other - more than in every other ending.

MR. HOUSE SCENARIO: THE HOUSE ALWAYS WINS

> *Mr. House's Securitron army took control of Hoover Dam and the Strip, pushing both the Legion and the exhausted NCR out of New Vegas. Mr. House continued to run New Vegas his way, a despotic vision of pre-War glory. The streets were orderly, efficient, cold. New Vegas continued to be the sole place in the wasteland where fortunes were won and lost in the blink of an eye.*

This scenario is characterized by the highest number of nodes and edges between all the endings (50 nodes and 62 edges), together with the highest number of alliances (33). This doesn't mean the cessation of all hostilities, rather it proves that siding with Mr. House leads to a peaceful scenario in

which most of the conflicts can be avoided. However the socio-political tensions remain, as the 9 hostile edges document.

What is also to notice is that the network is split in three different components, as a consequence of the destruction of the Brotherhood of Steel's bunker: since the minor faction would surely oppose Mr. House's regime, they were eliminated by the Courier on the orders of House, no questions asked. Veronica and Father Elijah are the only ones left alive (nobody knows where Elijah actually is[8] and Veronica is an *essential* NPC[9]). The permanence of hostile edges and the 3 components demonstrate the ambiguity of Mr. House's ruling: mostly concerned about the Strip's economic income, his calculations are always aimed at a future strangely similar to the pre-War past to which he longs to return, because of that, although ensuring peace and order with his Securitrons, he has little interest in the condition of the poorest neighbourhoods like Freeside and Westside and, in general, on the living conditions and everyday problems of the citizens.

Eigenvector Centrality, visualised in *Figure 6* reveals the five most central nodes: Mr. House (1), President Kimball (0,74), Colonel Moore (0,66), Big Sal (0,49) and Nero (0,49). Right after, there are NCR nodes, suggesting a sort of importance of the Republic in this scenario. In truth, after the defeat in Hoover Dam, the NCR was pushed out of New Vegas by House himself, and the bond with President Kimball remains neutral. The Legion has a likely fate.

Characters who serve as interfaces in this network following **Betweenness centrality** results are Mr. House (460), Colonel Moore (313) and President Kimball (247), names that also emerge from *Figure 6* visualisation. Other central characters are Mother Pearl (184), Julie Farkas (184), and Motor-Runner (130). These nodes are useful bridges from one part of the graph to another. The Legion, the Great Khans, the Crimson Caravan Company, the Omertas, and the Followers of the Apocalypse do not have an influent position in this ending.

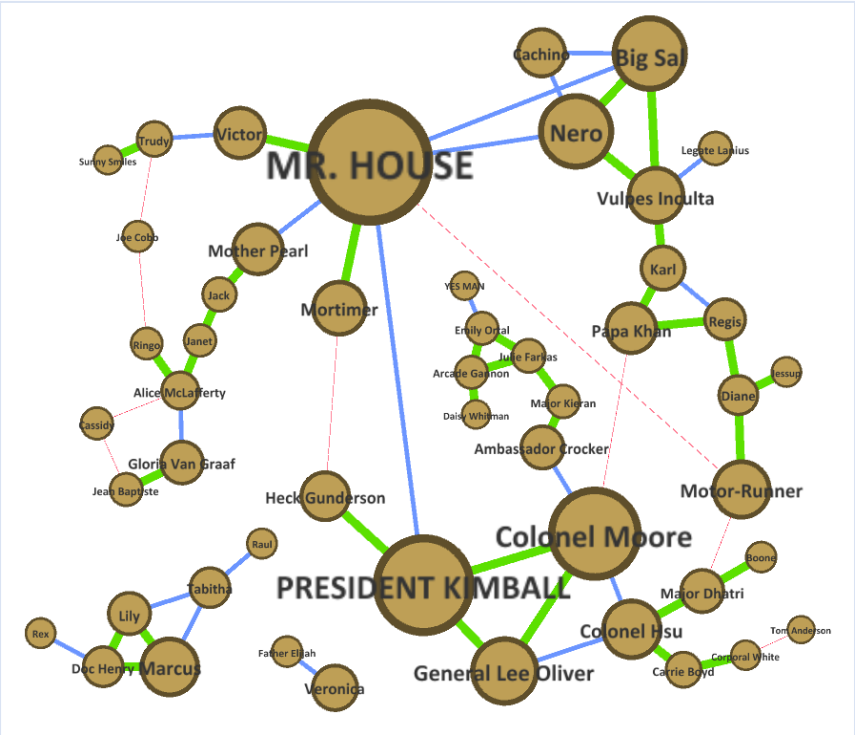


Figure 6. Mr. House ending scenario.

Observing the **Closeness centrality**'s highest values of *Table 6*, there are few factions on top (excluding the smaller components' nodes), namely Mr. House (0,31), NCR (Kimball and Moore), the Fiends (Motor-Runner), the Boomers (Mother Pearl). At any rate, a focus on the single factions reveals that

[8] Elijah will appear in the *Dead Money* DLC: https://fallout.fandom.com/wiki/Elijah and https://fallout.fandom.com/wiki/Sierra_Madre.

[9] It means she cannot be killed. Everything about essential characters here: https://fallout.fandom.com/wiki/Essential

other central nodes are Motor-Runner, Marcus, Big Sal, Papa Khan, and Mother Pearl. It is the first time the leader of the Boomers' isolationist tribe, Mother Pearl, appears as a central node. In this scenario, even if the Boomers supported the Courier - therefore Mr. House - in the second Battle of Hoover Dam, Mr. House has a neutral relation with Pearl. The wiki quotes: «Mr. House showed little interest on the Boomers, who eventually began venturing out of Nellis to meet and trade with travellers.»[10]

NCR SCENARIO: FOR THE REPUBLIC

> *The New California Republic celebrated its second victory at Hoover Dam, establishing definitive control over the entire Mojave Wasteland. Soon after, they negotiated terms to annex The Strip, Freeside, and many surrounding communities. The Mojave Wasteland, at long last, had entirely fallen under the NCR's banner.*

Similarly to the Legion's ending, here in the NCR scenario the winning faction of the second battle of Hoover Dam establishes itself as a sovereign power over the entire region. The violence of the battle and the involvement of most of the Mojave factions is testified by the low numbers of nodes and hostile edges remaining (respectively 41 and 7). However, this scenario bears the highest degree of density (0,059), suggesting that the NCR managed to integrate well into the social environment during the period between the battles: Dennis Crocker, the NCR's ambassador in the Strip, ensures a channel of communication with the Families and Mr. House himself; Elizabeth Kieran, allocated in Freeside, one of the poorest neighbourhoods, is at the head of a project for the distribution of food to the population; Colonel Hsu runs Camp McCarran, an airport converted to headquarters just outside the city, and with his men he is committed to eliminating marauding gangs like the Fiends. Nevertheless, the NCR domain introduces huge taxes which weigh mainly on small settlements like Goodsprings and Primm, reason why the new government is not praised by everyone.

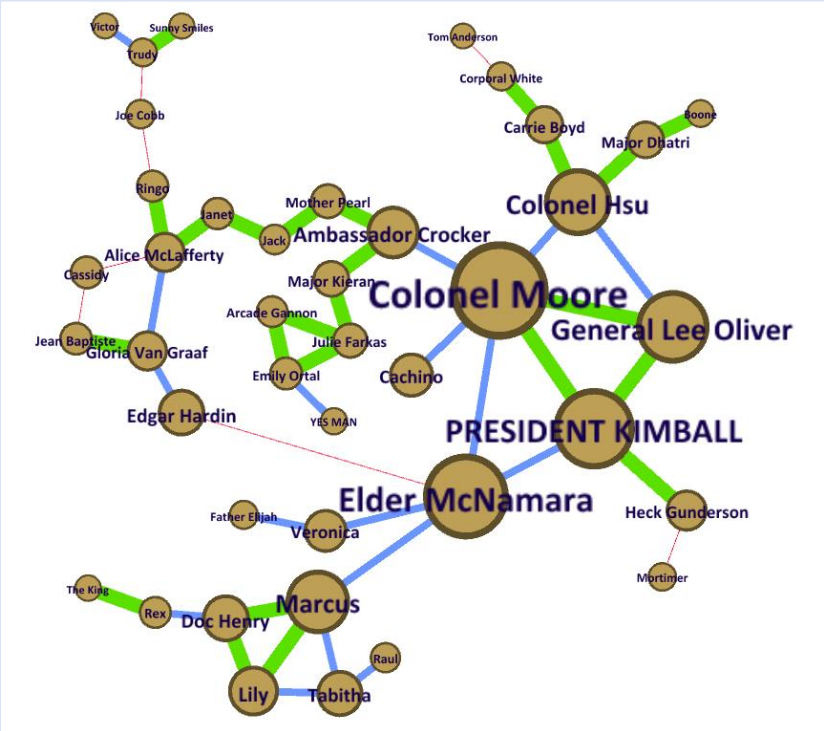


Figure 7. NCR ending network.

Betweenness Centrality's highest value goes to Elder McNamara (433), followed by four NCR characters and then Alice McLafferty, Gloria Van Graff, and Marcus. This centrality measure perfectly

[10] *Slide 6: Boomers* at this link: https://fallout.fandom.com/wiki/Fallout:_New_Vegas_endings#Slide_6:_Boomers.

describes the position of the two historically opposing factions[11]. In this scenario, the Brotherhood and the NCR declare an official truce in the Mojave, despite the continuous hostilities between the two in the west. Elder McNamara is responsible for the only connection between Jacobstown/Black Mountain and the rest of the network, and he also serves as shortest path for the NCR to reach Hardin and the Van Graff's; Colonel Moore links his NCR allies to the rest of the graph. These two nodes are also the ones with highest degree in the scenario.

The NCR node which stands out for highest **Closeness** is Colonel Moore (0,3), who comes right after Brotherhood of Steel's Elder McNamara. Super mutant Marcus from Jacobstown in third position with a Closeness centrality of 0,25, followed by Gloria Van Graff and Mother Pearl. In the NCR's ending, the mentioned representants of four minor factions seem to be the best-placed nodes to influence the entire network. At any rate, *Table 7* shows that the actual top five highest values are all assumed by members of the NCR.

[11] As a result of the Brotherhood's and NCR disagreement on how technology should be controlled, a series of violent confrontations took place in the past. Source: https://fallout.fandom.com/wiki/Brotherhood_War.

Conclusions and critique

And so the Courier's road came to an end... for now. In the new world of the Mojave Wasteland, fighting continued, blood was spilled, and many lived and died - just as they had in the Old World. Because war... war never changes.

As we could see, the situation in the four endings differs not only from the starting scenario, but also from case to case.

In summary, the fragmented and small Caesar's network shows how New Vegas would be if under a despotic government. Someone could argue that in Caesar's mind that was the only way to transform the Mojave into a true empire: «a militaristic, imperialist, autocratic, culturally homogeneous empire whose ruler holds undisputed power - a "Pax Romana" which would prevent humanity from ever fracturing itself again»[12]. But is the loss of all those nodes a fair price to pay to control the Mojave?

On the opposite, the Mojave of the NCR would seem a better world to live in. The connections between nodes are high and the density too: the New California Republic supports democracy, personal liberty, order, and the rule of law. Nevertheless, Mojave wasteland residents point out a worrying parallelism between the NCR's ideals and the old world's ones, the ones which led to nuclear holocaust in the first place.

About Mr. House, his victory defines a return to the origins, to New Vegas' pre-War glory, yet to an autocratic state in which democracy is not even mentioned. The House's graph is full of nodes and connections, though split. The winner here is not even so concerned about what is going on outside of his New Vegas, where the streets are *orderly*, *efficient*, *cold*. This climax seems to descend more and more towards an age of fear and tension, with no more individuality.[13]

Finally, the Independent New Vegas might seem the finest choice. The number of losses is low, only one component in the graph and elevate number of connections and density. The Courier, thanks to the help of Yes man, frees the Mojave. At this point, if the player previously upgraded the Securitron army, part of it is diverted to The Strip and any chaos on the streets is ended, quickly. On the other hand, if the player does not employ the army, anarchy will rule the city. Certainly, a state without an authority could easily turn into chaos, however will the courier be able to lead the entire Mojave?

Figure 8. The Strip.

[12] Quotation found at this link: https://fallout.fandom.com/wiki/Caesar.

[13] This mod is oddly fitting this analysis: https://www.nexusmods.com/newvegas/mods/74952.

We went through the analysis of various measures to find out about the future of New Vegas as a result of specific events, triggered or not by the game player. It is fundamental to state that the four endings under examination are accurately chosen between tons of possibilities inside *Fallout: New Vegas* world, which, being an RPG, offers the player an almost total control over it. The presented scenarios are created choosing the most realistic and logical paths a player could take once decided for one out of the four main endings, or, in other words, once the gamer has chosen their favourite faction. Although here there was no chance to address the problem, the game complexity and the implications of certain player's choices should not be limited to four scenarios: future studies should focus on far more scenarios, in order to include more shades of New Vegas.

Furthermore, the starting dataset could be boosted to create a network which includes every in-game character, without of course the NPCs the player cannot have a true dialogue with (e.g., Legion soldiers, members of the minor factions, children who do not give a quest, etc.). Also, another enhancement could be involving the DLC's characters to create an even bigger graph.

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Appendix

Table 3. Centrality values for starting scenario.

Label	Degree	EigenCentrality	Betweenness centrality	Closeness centrality
Mr. House	7	1	326,128571	0,241228
Caesar	5	0,840605	100,695238	0,231092
President Kimball	5	0,751885	301,519048	0,252294
Vulpes Inculta	5	0,673416	40,45	0,198556
Benny	5	0,660765	179,25	0,227273
Big Sal	4	0,631144	33,192857	0,202952
Nero	4	0,631144	33,192857	0,202952
Colonel Moore	5	0,532147	550,504762	0,272277
General Lee Oliver	3	0,411922	47,433333	0,238095
Legate Lanius	2	0,36545	0	0,192982
Emily Ortal	4	0,345706	126,5	0,222672
Colonel Hsu	4	0,323369	264,5	0,228216
Mortimer	2	0,306057	7	0,196429
Cachino	2	0,304047	0	0,169753
Karl	3	0,298311	33,452381	0,207547
Victor	2	0,278274	146,245238	0,215686
Papa Khan	3	0,276825	96,002381	0,228216
Ambassador Crocker	3	0,276363	465,838095	0,269608
Heck Gunderson	2	0,258956	13	0,203704
Yes man	2	0,257681	0	0,202952
Pacer	4	0,241891	591,754762	0,264423
Major Kieran	3	0,213832	164,5	0,246637
Jessup	2	0,210134	48,783333	0,197133
Julie Farkas	3	0,210015	143,75	0,229167
Regis	3	0,201389	37,366667	0,202206
Gloria Van Graff	4	0,20032	479,254762	0,243363
Marcus	4	0,193652	109	0,159884
Arcade Gannon	3	0,174175	54	0,203704
Lily	3	0,161039	25	0,152778
Alice McLafferty	4	0,156185	271,297619	0,214008
Doc Henry	3	0,148281	107	0,168712
Diane	3	0,146923	50,95	0,190972
Major Dhatri	3	0,137859	92	0,194346
Tabitha	3	0,135892	54	0,139241
Elder McNamara	3	0,124729	203	0,182119
Trudy	3	0,111818	153,411905	0,204461
Edgar Hardin	2	0,109758	228	0,208333
Carrie Boyd	2	0,108938	106	0,189003
The King	2	0,103972	179	0,22

Jean Baptiste	2	0,097784	19,119048	0,197842
Motor-Runner	2	0,090698	24	0,180921
Cassidy	2	0,088838	4,5	0,177994
Rex	2	0,084555	140	0,190972
Ringo	2	0,080688	111,828571	0,197133
Janet	2	0,073153	106	0,179153
Joe Cobb	2	0,066991	109,578571	0,196429
Veronica	2	0,055153	54	0,155367
Daisy Whitman	1	0,052646	0	0,169753
Raul	1	0,046315	0	0,122494
Corporal White	2	0,045434	54	0,16035
Boone	1	0,044486	0	0,163205
Jack	2	0,03865	54	0,153203
Sunny Smiles	1	0,036914	0	0,170279
Father Elijah	1	0,02254	0	0,134804
Tom Anderson	1	0,019258	0	0,138539
Mother Pearl	1	0,018158	0	0,133172

Table 4. Centrality values for Caesar's Legion scenario.

Label	Degree	EigenCentrality	Betweeness centrality	Closeness centrality
Vulpes Inculta	5	1	52	0,5
Caesar	4	0,746933	40	0,448276
Karl	3	0,616732	36	0,433333
Legate Lanius	2	0,59024	0	0,393939
Big Sal	2	0,502369	0	0,351351
Nero	2	0,502369	0	0,351351
Lily	3	0,481198	2	0,714286
Marcus	3	0,481198	2	0,714286
Regis	3	0,417627	22	0,351351
Doc Henry	3	0,411602	4	0,625
Tabitha	3	0,411602	4	0,625
Papa Khan	2	0,364767	0	0,333333
Arcade Gannon	2	0,297999	12	0,333333
Mortimer	2	0,297999	12	0,333333
Diane	2	0,186262	12	0,276596
Alice McLafferty	3	0,158469	11	0,6
Raul	1	0,152344	0	0,416667
Rex	1	0,152344	0	0,416667
Janet	2	0,12687	8	0,545455
Gloria Van Graff	2	0,108701	5	0,461538
Daisy Whitman	1	0,107339	0	0,254902
Heck Gunderson	1	0,107339	0	0,254902

Jack	2	0,090919	5	0,428571
Ringo	1	0,078728	0	0,4
Jessup	1	0,075017	0	0,220339
Jean Baptiste	1	0,055492	0	0,333333
Mother Pearl	1	0,048142	0	0,315789
Colonel Hsu	2	0,044399	1	1
Trudy	2	0,044399	1	1
Carrie Boyd	1	0,031247	0	0,666667
Major Dhatri	1	0,031247	0	0,666667
Sunny Smiles	1	0,031247	0	0,666667
Victor	1	0,031247	0	0,666667
Ambassador Crocker	1	0,014476	0	1
Major Kieran	1	0,014476	0	1
Tom Anderson	0	0	0	0
Veronica	0	0	0	0
Yes man	0	0	0	0

Table 5. Centrality values for Independent New Vegas scenario.

Label	Degree	EigenCentrality	Betweeness centrality	Closeness centrality
Yes man	7	1	381,833333	0,142415
Arcade Gannon	4	0,765812	57,2	0,219048
Emily Ortal	3	0,654576	42,033333	0,248649
Julie Farkas	3	0,526558	127,4	0,223301
Cachino	3	0,504218	168	0,200873
Daisy Whitman	2	0,50392	0	0,223301
Pacer	4	0,44176	197,733333	0,172285
Major Kieran	3	0,411435	142,066667	0,192469
Elder McNamara	5	0,40823	322,333333	0,169118
Gloria Van Graff	4	0,404207	261,266667	0,234694
Ambassador Crocker	3	0,378802	107,333333	0,220096
Motor-Runner	2	0,362981	171,4	0,197425
Mother Pearl	2	0,341917	126,266667	0,214953
Big Sal	3	0,341436	43	0,231156
Nero	3	0,341436	43	0,196581
Colonel Moore	3	0,33902	280,333333	0,244681
Mortimer	2	0,319367	45	0,198276
Alice McLafferty	4	0,307956	287,066667	0,235897
Marcus	3	0,29564	133	0,220096
Edgar Hardin	2	0,270956	129	0,169118
Vulpes Inculta	3	0,246824	45	0,128492
Colonel Hsu	3	0,231526	272	0,243386
Lily	3	0,226468	26,666667	0,199134
Major Dhatri	3	0,219306	199,733333	0,212963

Tabitha	3	0,213113	45	0,146965
Jean Baptiste	2	0,194639	12,466667	0,237113
The King	2	0,183876	67	0,149837
Cassidy	2	0,17377	6,666667	0,25
Janet	2	0,161373	129,6	0,146497
Veronica	2	0,161002	45	0,166065
Jack	2	0,159869	122,6	0,23
Ringo	2	0,148285	168	0,162544
President Kimball	1	0,137611	0	0,195745
Doc Henry	2	0,124164	16	0,212963
Carrie Boyd	2	0,110852	88	0,252747
Rex	2	0,110819	36	0,169118
Joe Cobb	2	0,095461	129	0,177606
Heck Gunderson	1	0,094973	0	0,206278
Karl	1	0,082565	0	0,175573
Trudy	3	0,082158	89	0,165468
Raul	1	0,076636	0	0,186235
Boone	1	0,075086	0	0,198276
Corporal White	2	0,060696	45	0,252747
Father Elijah	1	0,057512	0	0,193277
Victor	1	0,039897	0	0,128492
Sunny Smiles	1	0,039897	0	0,128134
Tom Anderson	1	0,029117	0	0,183267

Table 6. Centrality values for Mr. House scenario.

Label	Degree	EigenCentrality	Betweeness Centrality	Closeness Centrality
Mr. House	7	1	460,066667	0,310606
President Kimball	4	0,747141	247,366667	0,292857
Colonel Moore	5	0,669902	313,433333	0,286713
Big Sal	4	0,492507	46,166667	0,254658
Nero	4	0,492507	46,166667	0,254658
General Lee Oliver	3	0,420641	28,1	0,261146
Colonel Hsu	4	0,341766	142,5	0,244048
Marcus	3	0,333336	2	0,714286
Motor-Runner	3	0,328699	130,133333	0,269737
Vulpes Inculta	4	0,314048	63	0,230337
Mortimer	2	0,293882	11	0,241176
Victor	2	0,268031	125	0,25625
Mother Pearl	2	0,26291	184	0,257862
Papa Khan	3	0,262351	72,333333	0,245509
Heck Gunderson	2	0,243751	7,1	0,230337
Cachino	2	0,236895	0	0,205
Veronica	1	0,208445	0	1
Karl	3	0,196277	38,666667	0,22905

Ambassador Crocker	2	0,186657	210	0,239766
Major Dhatri	3	0,185338	79,3	0,251534
Gloria Van Graff	2	0,181796	19,5	0,149091
Lily	3	0,176239	2	0,714286
Regis	3	0,164992	27,666667	0,22905
Tabitha	3	0,152967	4	0,625
Doc Henry	3	0,152967	4	0,625
Diane	3	0,145008	60	0,235632
Alice McLafferty	4	0,125088	121,5	0,172996
Carrie Boyd	2	0,10318	78	0,20098
Trudy	3	0,100673	107	0,221622
Jack	2	0,089388	157	0,22043
Julie Farkas	3	0,085352	148	0,175966
Major Kieran	2	0,080494	180	0,20398
Legate Lanius	1	0,080229	0	0,188073
Jean Baptiste	2	0,075888	0,5	0,13099
Arcade Gannon	3	0,074622	40	0,152416
Emily Ortal	3	0,074622	40	0,152416
Janet	2	0,06992	131	0,193396
Cassidy	2	0,068358	19,5	0,149091
Ringo	2	0,064427	20	0,171548
Joe Cobb	2	0,056396	47	0,193396
Father Elijah	1	0,051348	0	1
Boone	1	0,05051	0	0,20197
Raul	1	0,044807	0	0,416667
Rex	1	0,044807	0	0,416667
Jessup	1	0,042323	0	0,191589
Corporal White	2	0,040071	40	0,169421
Sunny Smiles	1	0,032165	0	0,182222
Yes man	1	0,029492	0	0,132686
Daisy Whitman	1	0,029492	0	0,132686
Tom Anderson	1	0,016622	0	0,14539
Yes man	1	0,029492	0	0,136729
Tom Anderson	1	0,016622	0	0,151786
Sunny Smiles	1	0,036914	0	0,170279
Father Elijah	1	0,02254	0	0,134804
Tom Anderson	1	0,019258	0	0,138539
Mother Pearl	1	0,018158	0	0,133172

Table 7. Centrality values for NCR scenario.

Label	Degree	EigenCentrality	Betweeness centrality	Closeness centrality
Colonel Moore	6	1	365,5	0,300752
Elder McNamara	5	0,829386	433,5	0,307692
President Kimball	4	0,770811	86	0,272109
General Lee Oliver	3	0,664022	9	0,245399

Colonel Hsu	4	0,588843	181	0,248447
Marcus	4	0,543025	207	0,254777
Ambassador Crocker	3	0,394342	230,5	0,268456
Lily	3	0,358756	3	0,209424
Doc Henry	3	0,316879	76	0,209424
Edgar Hardin	2	0,314247	221,5	0,27027
Tabitha	3	0,306634	39	0,207254
Cachino	1	0,280168	0	0,232558
Veronica	2	0,262163	39	0,239521
Heck Gunderson	2	0,239447	39	0,217391
Gloria Van Graff	3	0,227038	208	0,240964
Alice McLafferty	4	0,22627	215,5	0,220994
Carrie Boyd	2	0,201529	76	0,204082
Major Dhatri	2	0,191834	39	0,20202
Major Kieran	2	0,180298	144	0,222222
Julie Farkas	3	0,162009	111	0,187793
Mother Pearl	2	0,157541	86,5	0,238095
Emily Ortal	3	0,133143	39	0,160643
Cassidy	2	0,132974	4,5	0,183486
Jean Baptiste	2	0,129321	12	0,197044
Janet	2	0,124497	61	0,205128
Ringo	2	0,122706	144	0,188679
Rex	2	0,119063	39	0,175439
Arcade Gannon	2	0,116804	0	0,16
Jack	2	0,101798	68,5	0,215054
Raul	1	0,096119	0	0,172414
Joe Cobb	2	0,086223	111	0,163265
Corporal White	2	0,080546	39	0,171674
Father Elijah	1	0,077894	0	0,194175
Trudy	3	0,077031	77	0,142857
Mortimer	1	0,070845	0	0,179372
Boone	1	0,060283	0	0,168776
Joe Cobb	2	0,056396	19,883333	0,190299
Yes man	1	0,054341	0	0,138889
Father Elijah	1	0,051348	0	0,208163
Boone	1	0,05051	0	0,203187
Raul	1	0,044807	0	0,179577
Rex	1	0,044807	0	0,179577
The King	1	0,04306	0	0,149813
Jessup	1	0,042323	0	0,194656
Corporal White	2	0,040071	50	0,178322
Sunny Smiles	1	0,037701	0	0,125392
Victor	1	0,037701	0	0,125392

Tom Anderson	1	0,032383	0	0,147059
Sunny Smiles	1	0,032165	0	0,181495
Daisy Whitman	1	0,029492	0	0,136729
Yes man	1	0,029492	0	0,136729
Tom Anderson	1	0,016622	0	0,151786