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SOLVING RESOURCE AND PROCESS OPTIMIZATION PROBLEMS USING AI PLATFORMS

VICTORIA LOZAN
PhD
Department of Information Technology and Information Management
Academy of Economic Studies of Moldova
Chisinau, Republic of Moldova
lozan.victoria@ase.md
ORCID ID: 0000-0002-5869-8515

Abstract: In the last period, the use of artificial intelligence (AI) has seen a significant expansion in various socio-economic fields, with the aim of making the time needed to perform various tasks more efficient. The academic field is no exception to this trend, being characterized by an increasing adoption of AI platforms, especially by students. These platforms are used to get quick but not always correct and complete solutions for lab assignments, seminars and assessments.

The present work focuses on testing free variants of AI platforms, such as Chat GPT and Copilot, in the context of solving problems specific to the Operational Research domain. The covered issues include aspects such as activity planning, stock management and analysis of queuing systems. The main goal of the research is to evaluate the effectiveness of these AI tools in solving complex academic problems.

In order to carry out a rigorous evaluation of the results generated by AI platforms, practical examples from the manual of Gamețchi and Solomon (2015) are used, where the solutions are already known. This approach allows a detailed comparison between the results provided by the AI and the solutions established in the manual, thus facilitating the identification of the strengths and limitations of each platform. Comparative analysis provides an in-depth understanding of the precision and utility of these tools in the academic context.

As a result of the research, conclusions were obtained regarding the use of these tools in the educational process and their impact on uninitiated people in the field of problems that require solutions.

Keywords: artificial intelligence, activity planning, stock management, analysis of queuing systems

JEL Classification: C02, C44, C50, C51, C65

1. Introduction

AI-based products are used in various fields for different purposes, such as creating presentations using templates, generating graphs and reports, studying languages, developing personalized programs for sports and nutrition, and many others. The paper addresses the use of Copilot and Chat GPT products. Copilot is an AI-based personal chat assistant developed by Microsoft, formerly known as Bing Chat, released on the market under this name in the fall of 2023. Copilot is available in the Microsoft Edge browser and on Windows 11 PCs. It's a free service for eligible users and those with a Microsoft account. It is typically used for chat discussions with text, voice, and image capabilities, document and web page summarization, image creation, web substantiation, etc. Microsoft also offers Copilot for Microsoft 365 with an annual subscription of €337.20 (€28.10 user/month), used in Microsoft applications. A separate license for an eligible Microsoft 365 plan is required prior to purchase. Rates are available on the Microsoft 365 Copilot page (Microsoft 365 Copilot, 2024).

Another product used is Chat GPT - an AI model created by Open AI, based on the Generative Pre-trained Transformer – 4 (GPT) architecture, one of the most advanced versions currently available, according to the developers. He is trained to generate texts and answer questions coherently and relevantly based on the data he has learned from various information sources. The free plan offers copywriting assistance, troubleshooting, etc., access to GPT-4o mini, limited access to GPT-4o, limited access to advanced data analysis, file upload, detailed insight, web browsing, and custom GPTs and has a limitation on the number of messages. For early access to new chat features Open AI o1-preview, Open AI o1-mini, as well as access to GPT-4o, GPT-4o mini, GPT-4, more messages for GPT-4o, access to advanced analysis of data, uploading files, detailed perception and web browsing, image generation with DALL·E, creating and using custom GPTs requires a monthly subscription of $20, Plus plan. GPT also has the Team plan with more generous features and a $25 per month rate. GPT Chat offers users the opportunity to familiarize themselves with other AI-based products available in the Explore GPTs section of the menu displayed on the left side of the web page if the chat is accessed from a browser. The products are organized by categories to facilitate their quick finding. There are also proposed GPTs created by the GPT team that are oriented towards specific areas of interest, for example: DALL·E – for image generation, Data Analyst – for data analysis and visualization, Coloring Book Hero – for creating coloring book pages, Planty – expert in plant care, and other useful products.

In the paper, the free plan is used to solve some problems from the Operational Researches domain. The accuracy and correctness of the response provided by Chat GPT and Copilot is analyzed.

2. The Problem of Planning a Complex of Activities

The problem of planning a complex of activities is a challenge in the field of optimization and projects management, which involves the efficient organization and ordering of a set of interrelated activities. The goal is to achieve a specific goal under given conditions, such as limited resources (time, people, money) and constraints (deadlines, sequencing of activities). To test the results provided by the chats, the example on page 82 of Gamețchi and Solomon (2015) was used, for which it was required to build the network-graph, to determine the critical activities, critical events and time parameters. Information about the project is presented in the Table 1.

Table 1. Project characteristics.

The activity	The following activities	Duration
A	B, C	3
B	D, E, F	8
C	G	5
D	G	6
E	-	15
F	H	4
G	-	7
H	-	6

Source: *Gamețchi and Solomon (2015) page 82.*

According to the source of Gamețchi and Solomon (2015), the critical path has the value 26, the critical events: x1, x2, x3, x6; critical activities: A, B and E; the total time reserve for activity C is 11, D – 2, F – 5, G – 2, H – 5; the free time reserve for activity C is 9, H – 5; the safe independent time reserve for activity C is 9. The network-graph of the project, critical activities and critical events are shown in Figure 1. The critical path consists of activities A → B → E. Critical events and activities are highlighted on the network-graph in red. In Gamețchi and Solomon (2015), the values of the earliest/latest event times and the earliest/latest start and finish times of the activities are also found.

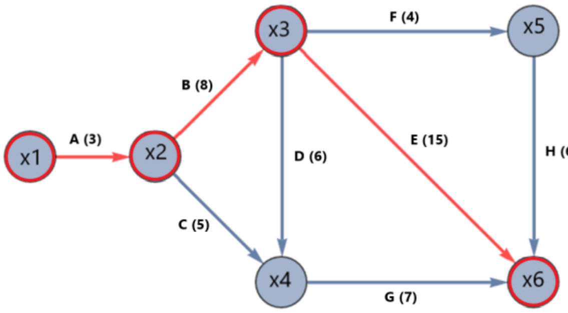

Figure 1. Network-graph, critical events and activities.
Source: *Adapted by the author based on the example from Gamețchi and Solomon (2015).*

GPT chat provided the resolution steps. First, he once again defined the activities and the relationships between them, then described the construction of the network-graph, specified the initial event, the consecutiveness of activities and events until the final event is reached. The user can draw the graph taking into account the description provided by the chat. The network-graph constructed by Chat GPT is shown in Figure 2.

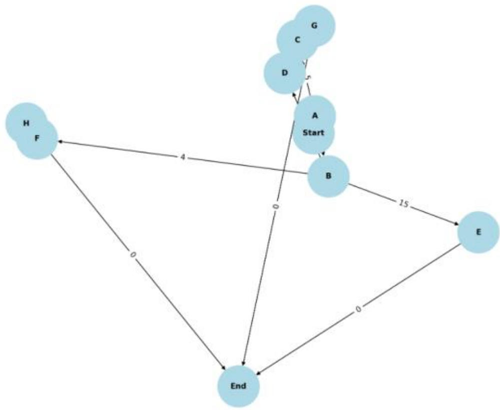

Figure 2. Network-graph of the project by GPT.
Source: *Chat GPT.*

If Figure 2 is analyzed, then the clear representation of the network-graph cannot be determined, the data is overlapping and difficult to read. The chat determined its next steps, then hung up and informed the user that the number of questions had been exceeded. A question follows: „*Create the network-graph for the proposed problem?*", to which the chat comes with the answer in Figure 3.

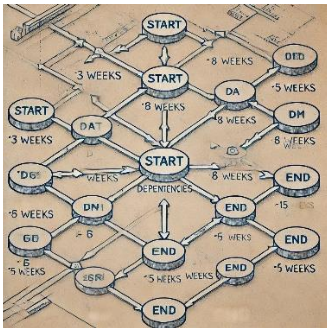

Figure 3. The new network-graph of the project by GPT.

Source: *Chat GPT.*

The representation in Figure 3 makes things even more confusing. It was pressed to get the answer to „*What is the critical path?*". The chat provided the answer „*The critical path is: Start → A → B → E → End, and it takes 26 weeks.*", which is correct. Next comes the question: „*What are the time parameters of the project?*". The obtained result is presented in Table 2.

Table 2. Time parameters of the project.

The activity	Duration of activity	**Gamețchi and Solomon (2015)**				**Chat GPT**				**Copilot**			
		$T_{ij}^{s.mi}$	$T_{ij}^{s.ma}$	$T_{ij}^{e.mi}$	$T_{ij}^{e.ma}$	$T_{ij}^{s.mi}$	$T_{ij}^{s.ma}$	$T_{ij}^{e.mi}$	$T_{ij}^{e.ma}$	$T_{ij}^{s.mi}$	$T_{ij}^{s.ma}$	$T_{ij}^{e.mi}$	$T_{ij}^{e.ma}$
A	3	0	0	3	3	0	0	3	3	0	0	3	3
B	8	3	3	11	11	3	3	11	11	3	3	11	11
C	5	3	14	8	19	3	**7**	8	**12**	3	**3**	8	**8**
D	6	11	13	17	19	11	**12**	17	**17**	11	**11**	17	**17**
F	4	11	16	15	20	11	**17**	15	**21**	**15**	**15**	**19**	**19**
E	15	11	11	26	26	11	11	26	26	11	11	26	26
G	7	17	19	24	26	**8**	19	**15**	26	**19**	19	**26**	26
H	6	15	20	21	26	15	20	21	26	**19**	**19**	**25**	**25**

Sourse: *Made by the author based on the source Gamețchi and Solomon (2015) and the results provided by Chat GPT and Copilot.*

From the data presented in the table, it can be noted that for three activities (C, D, F) the values of the latest possible start time and the latest possible end time of the activity are incorrectly calculated by Chat GPT. Also, incorrect response is provided for the earliest possible start time and earliest possible finish time values for activity G. It can be noted that 25% of the values in the table calculated by Chat GPT are incorrect.

Copilot summarizes the requirements of the problem and provides a brief theoretical background. Propose the result for the time parameter values shown in Table 2, about 44% of them are incorrect. The results for activities C, D, F, G and H are wrong. As for the critical path, Copilot provides the answer: „*The critical path is A → B → D → G, with a total duration of 24 weeks.*" The question „*Are you sure this is the critical path?*" was introduced. The Copilot, after repeating the calculations, gives the answer: „*Yes, the critical path is correct and consists of activities A → B → D → G, with a total duration of 24 weeks.*" – it is not true. The Copilot was asked to create the network-graph of the project. The chat offered several options, shown in Figure 4. None of them correspond to the network-graph of the project presented in Gamețchi and Solomon (2015).

If the chats are queried on another day with the same problem, then the solution may differ. Other values for time parameters and another critical path may be presented. Chat GPT becomes solidary with Copilot regarding the value of the critical path. The approach to the problem differs, because of the tools used in the solution. In the process of finding and offering solutions, the sources approached may not always be consistent and correct. Therefore, the solutions proposed by the chat are not necessarily correct.

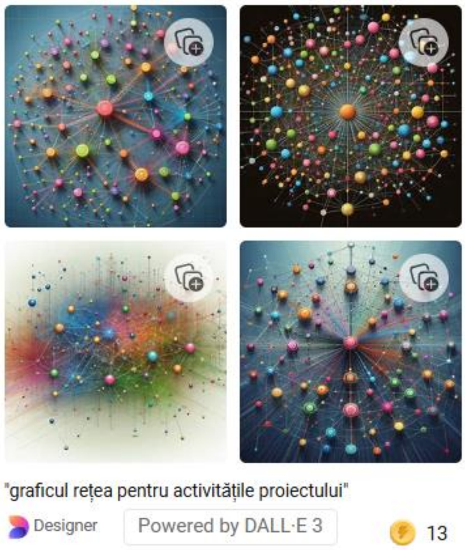

Figure 4. The network-graph variants of the project offered by Copilot.

Source: *Copilot.*

Both tools used in solving the problem provided incomplete and incorrect data. However, part of the calculations corresponds to those presented in Gamețchi and Solomon (2015).

3. Queuing Systems with Infinite Queue

Chat capabilities were tested using the example on page 165 of Gamețchi and Solomon (2015): „*In a supermarket, three cash registers operate with the same productivity. It has been observed that during an hour an average of 40 buyers arrive and the average service time of a buyer is 3 minutes. Determine: the stationarity probability of the cash registers (P_0); the average tail length ($\bar{r}$); the average number of shoppers in the store ($\bar{k}$); the average time a shopper waits to be served ($\bar{t}_{wait.}$); the average time the customer is in the store ($\bar{t}_{sist.}$). Establish the conclusion about the effectiveness of the supermarket's activity.*"

The result in Gamețchi and Solomon (2015) is:

- the stationarity probability of the cash registers $P_0 \approx 0{,}11$;
- the average tail length $\bar{r} = 0{,}88 \approx 1$ buyer;
- the average number of shoppers in the store $\bar{k} = 2{,}88 \approx 3$ customers;
- the average time a shopper waits to be served $\bar{t}_{wait.} = 1{,}32$ min.;
- the average time the customer is in the store $\bar{t}_{sist.} = 4.32$ min.
- *Conclusion:* The activity of the supermarket must be considered efficient.

The GPT chat gives a brief presentation of the theoretical aspects and asks the user if there is a need to perform the full calculations using the proposed formulas. At some times may be displayed the message „*It seems like I can't do more advanced data analysis right now. Please try again later.*"
The proposed result of GPT is:

- $P_0 \approx 0{,}1111$;
- $\bar{r} = 0{,}89 \approx 1$ shopper;
- $\bar{k} = 2{,}89 \approx 3$ customers;
- $\bar{t}_{wait.} = 1{,}33$ min.;
- $\bar{t}_{sist.} = 4{,}33$ min.
- *Conclusion*: The supermarket operates quite efficiently, with a low waiting time and a relatively short queue.

The answer provided by Chat GPT, in this case, coincides with the answer in Gamețchi and Solomon (2015).
Copilot, for the proposed example, gives the following answer:

- $P_0 \approx 0{,}111$;
- $\bar{r} = 0{,}099$ buyer;
- $\bar{k} = 2{,}099$ shoppers;
- $\bar{t}_{wait.} = 0{,}1485$ min.;
- $\bar{t}_{sist.} = 3{,}1485$ min.
- *Conclusion*: The operation of the supermarket is efficient.

The results obtained with the help of the Copilot do not coincide with those of Gamețchi and Solomon (2015). One of the possible causes may be the incorrect establishing of the waiting system type or the formulas used. If a value is determined incorrectly, then all subsequent calculations can no longer be accurate and correct. If the user does not master the domain sufficiently, Copilot can lead him to wrong answers.
Analyzing that example, it can be seen that Chat GPT provided a correct answer, exceeding the possibilities of Copilot.

4. Stock Management

Stock management issues are common challenges encountered in effectively managing goods inventory. They are studied in the course in order to be able to avoid, in the future field of activity, overstocks, insufficient stocks, inaccurate demand forecasts, problems related to stock rotation, high management costs, problems with suppliers, etc. There are different management models used depending on the activity profile of the enterprises. Will test chat capabilities using the example on page 202 of Gamețchi and Solomon (2015), which reflects the optimal lot size for several types of products: „*A store sells items of two types. The demand during the period of T=30 days is respectively of $S_1 = 500$ units and $S_2 = 1000$ units of articles. The fixed costs of selling a lot is $c_2 = 60$ m.u., but the unit keeping cost $c_{11} = 0{,}1$ m.u./day and respectively $c_{12} = 0{,}05$ m.u./day. Determine the optimal number of lots (n^*), the optimal lot size for each item type (q_1^*, q_2^*), the optimal delivery interval (τ^*).*"
The solution to the problem is:

- $q_1^* = 100$ units;
- $q_2^* = 200$ units;

- $\tau^* = 6$ days;
- $n^* = 5$ lots.

Copilot for the analyzed stock management problem provided the following results:

- $q_1^* = 141{,}42$ units;
- $q_2^* = 282{,}84$ units;
- $\tau^* = 8{,}47$ days;
- $n^* = 3{,}54$ lots.

It is noticed that the result is not a correct one. The cause is the formulas used by Copilot to get the result - they are not correct. The formula used for optimal lot size corresponds to mono-product stock: $q_i^* = \sqrt{\frac{2Sc_2}{Tc_{1i}}}$, it was necessary to use formulas for inventories with several types of products: $q_i^* = S_i \Big/ \sqrt{\frac{T\sum_{i=1}^{k} c_{1i} \cdot S_i}{2c_2}}$ - the correct formula.

Querying the GPT Chat returned the following results:

- $q_1^* = 141{,}42$ units;
- $q_2^* = 282{,}84$ units;
- $\tau^* = 7{,}5$ days;
- $n^* = 3{,}54 \approx 4$ lots.

Because Chat GPT has rounded the value for the optimal number of lots, the optimal delivery interval differs from that provided by Copilot. Otherwise, all values are identical because Chat GPT used the same calculation formulas as Copilot.

For multi-product stock management, chats have proven to be ineffective. For the example on page 188 of Gamețchi and Solomon (2015) – mono-product stocks, the chats gave the same results as in the manual.

5. Results Provided by Google AI

There is a wide range of products developed for users with the same goal - to facilitate the realization of activities. Another product is Gemini (Google AI) developed by Google. The free plan (limited) may be used or the advanced plan (with the latest innovations) for $19.9 per month.

The problems analyzed above are offered for solution in the Gemini chat. For each problem, the chat provided theoretical information and solution steps. For the planning problem in point 2, getting the concrete numerical values involved a long series of questions. Initially the chat sampled the results for the time parameters only for the first three activities. Table 3 shows all the numerical values offered by the chat. The incorrect values are highlighted in red, approximately 38%.

Table 3. Project time parameters provided by Gemini.

The activi-ty	Dura-tion of activity	**Gamețchi and Solomon (2015)**				**Gemini**			
		$T_{ij}^{s.min}$	$T_{ij}^{s.max}$	$T_{ij}^{e.min}$	$T_{ij}^{e.max}$	$T_{ij}^{s.min}$	$T_{ij}^{s.max}$	$T_{ij}^{e.min}$	$T_{ij}^{e.max}$
A	3	0	0	3	3	0	0	3	3
B	8	3	3	11	11	3	3	11	11
C	5	3	14	8	19	3	**3**	8	**8**
D	6	11	13	17	19	11	**11**	17	**17**
F	4	11	16	15	20	11	**11**	15	**15**
E	15	11	11	26	26	11	11	26	26
G	7	17	19	24	26	**8,17**	**15**	**15**	**22**
H	6	15	20	21	26	15	**15**	21	**21**

Source: *Made by the author based on the source Gamețchi and Solomon (2015) and Gemini.*

Gemini does not provide clear and correct network-graph representation, a variant is shown in Figure 5, which has no tangent to the network-graph of the analyzed project, it is a network-graph on the internet. The critical path, according to the chat, has a value of 21 and it is: A → B → D → G → H.

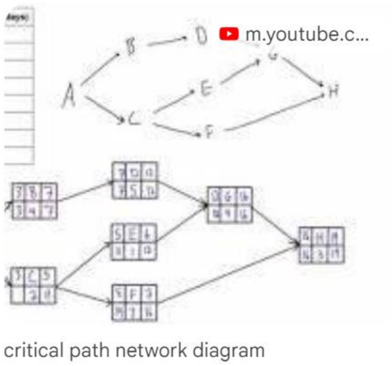

Figure 5. The network-graph of the project offered by Gemini.
Source: *Gemini.*

For the problem analyzed in point three, Gemini offers the answer:

- $P_0 \approx 0{,}2963$;
- $\bar{r} = 1{,}32$ clients;
- $\bar{k} = 2{,}19$ clients;
- $\bar{t}_{wait.} = 2$ min.;
- $\bar{t}_{sist.} = 5$ min.

Analyzing the result, it is observed that no value coincides with those in Gamețchi and Solomon (2015).

The problem of managing the stock with several types of products, analyzed in point four, is solved by the Gemini chat and the results are obtained:

- $q_1^* = 63{,}25$ units;
- $q_2^* = 89{,}44$ units;
- $\tau_1^* = 3{,}8$ days;
- $\tau_2^* = 2{,}7$ days;

- $n_1^* = 7{,}89$ lots;
- $n_2^* = 11{,}11$ lots.

It is easy to see that the results are totally different from those of Gamețchi and Solomon (2015). Values for each product type are shown for both the optimal delivery interval and the optimal number of lots. The model used by Gemini is wrong and provides compromised results.

From the above, it can be realized that the chat developed by Google also provides incorrect and incomplete results. These tools cannot be used to obtain correct and complete answers to Operational Research problems.

Conclusions

Chats based on AI technology are increasingly used to quickly get answers to various questions. They are especially useful due to quick access to information, as AI can process and extract information from a wide range of sources, without the need for the user to manually search through multiple sites or go through documentation. Based on previous questions and interactions, these systems can learn user preferences and provide more relevant and tailored responses. Although AI models like those in GPT do not self-train in real-time after current interactions, they are initially trained on massive amounts of data, and subsequent models are always improved with new data. In some cases, they may be linked to external, up-to-date data sources to provide up-to-date information. AI-powered chats can automate repetitive tasks and execute complex commands, saving time and effort for users. The listed features make AI a valuable tool for solving problems, finding information, and even making data-driven decisions.

However, the results obtained are not always correct or complete, because essentially a machine can make mistakes. These tools are effective when the user has knowledge in the field, otherwise there is a risk of being misdirected. AI chats require guidance and additional questions to provide an appropriate response. In some cases, the user is advised to turn to other specialized applications for complex calculations or data analysis. Analyzed chats cannot be used to obtain accurate and complete solutions to problems of operational researches domain.

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