надав найякісніший результат. Під час кожної ітерацій у запит вносилися зміни, щоб отримати все кращі і релевантніші питання.

Далі були об'єднані дві вищеописані частини програми, що дало змогу зберігати тести від різних викладачів різних факультетів та кафедр, а також відповіді на ці питання від студентів. Це відкрило шлях до аналізу даних, який може надати висновки про навчання студентів та покращити його.

Результати показали, що розроблена система ефективно генерує тестові питання з мінімальною кількістю помилок. Питання відповідають навчальній програмі та підходять для оцінювання знань на різних етапах навчання. Система автоматично адаптує складність питань відповідно до рівня студентів, що підвищує точність оцінювання. Тестування підтвердило, що автоматизація створення тестів значно скорочує час підготовки матеріалів, даючи змогу викладачам зосередитися на інших аспектах.

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## ADVERTISING STRATEGY: A GAME THEORY APPROACH

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Determining just when and where to place ads in today's modern, highly competitive landscape in order to maximize impact and return on investment poses a difficult choice for companies. As audiences have continued to fragment across multiple platforms and time slots, how media advertising is placed has become increasingly critical amidst such intense competition for attention [1]. This paper aims to explore how game theory can provide insight into the rival firms' strategic dynamics of advertisement timing and arrive at an optimal decision in this respect.

The issue of timing can hardly be overestimated in this realm, considering that companies operating within today's digital platform-and-traditional-media-laden world must closely consider not only their own optimal timing but also the strategic

choices of their competitors. When multiple firms compete for the same segments of audiences, their advertisements intersect and cause less efficient advertising because of the audience's fatigue and diverted attention. The consequence, therefore, tends to strategic interdependence of decisions within the competitors, which makes game theory an ideal vehicle of analysis [1]. The work offers a close-up view of a basic game-theoretic model of advertisement timing strategies by two competing companies. Analyzing this simplified example, yet some basic lessons can be derived on how strategic interaction in advertising timing decisions works, while simultaneously developing some practical guidelines for companies facing such decisions.

Game theory offers a systematic approach to studying the interactions of multiple decision-makers whose conscious choices affect one another's payoffs. Within the timing of advertising, two critical concepts operate.

First, there is a Nash Equilibrium: given the player's decision depending on the other players, nobody can be better off by unilaterally changing his or her move.

Then, Zero-Sum vs. Non-Zero-Sum Games: Although many consider traditional advertising competitions to be zero-sum games – a company's gain is another one's loss – the actuality of advertisement timing often puts forward non-zero-sum aspects whereby firms achieve mutual benefit through strategic coordination.

Consider two firms, A and B, operating in the same marker with similar products or services. Each firm must choose one of two major timing strategies:

1. Peak Hours (P): This is when the audience is most engaged.

2. Off-Peak Hours (O): This is when the audience are fewer but still remarkably engaged, or at least much higher than during other times.

Key assumptions of this model are that:

• Both firms have a fixed advertising budget.

• The audience's attention is limited, which could be diluted by the presence of many competing ads.

• Companies aim at maximizing the effectiveness of their advertisement, defined as audience reach and engagement.

• The effectiveness of an ad will depend on both timing choice and competitor behavior. Numbers represent relative effectiveness scores on a scale from 1 to 10.

The following payoff matrix illustrates the outcomes for both companies under different timing combinations.

Table 1 – Payoff matrix

| Company A / Company B | Peak | Off-peak |
|---|---|---|
| Peak | (5,5) | (8,6) |
| Off-peak | (6,8) | (7,7) |

Numbers represent relative effectiveness scores on a scale from 1 to 10. The reduction to 5 for simultaneous peak-hour advertising reflects estimated losses from direct competition for audience attention. The asymmetric 8,6 scores represent the trade-off between peak audience access and competitive interference, while the 7,7

off-peak equilibrium balances smaller audience size against clearer messaging opportunities.

By analyzing this payoff matrix, several key insights arise. They achieve only a moderate level of success when both companies choose to advertise during peak hours since their dilution of audience attention reduces the attention any one company can command. It is represented in our model by having both companies get a score of 5 out of 10 in the above case. The messages from one company fight for viewer mindshare and interfere with messages from the other company.

The more interesting dynamics come up when companies employ different timing strategies. In these cases, both firms can achieve far greater payoffs-the peak hours company reaches an 8 while the off-peak company reaches a 6, demonstrating that such avoidance of direct temporal competition can be beneficial to both, even when gains are not equal. Most interestingly perhaps, the Nash equilibrium in this scenario occurs when both companies choose off-peak hours with scores of 7 for each firm. Although this is perhaps not the theoretical optimum for either firm, it does constitute a steady state that is superior to relentless competition in prime time. This equilibrium point implies that firms may naturally converge toward temporal differentiation in their advertising strategy even in the absence of overt coordination.

Our analysis yields a number of key strategic implications for advertising strategy. Here, one of the most interesting implications brings forth the principle of competitive avoidance: the efficiency of advertising by a firm can be enhanced by selecting time slots that differ from those of its competitors. Direct coordination of firms would involve several legal and practical difficulties, but the market mechanisms would imply, naturally enough, a sort of implicit coordination where consistent patterns of timing would emerge in a self-organizing fashion among competitors.

Of course, these theoretical implications are reflected in the actual advertising practices of the real world. For example, large beverage companies hold key temporal positioning in television advertising by intentionally staggering their advertising schedules to catch prime time for maximum impact with minimum direct competition [2]. In fact, similar patterns are followed in the online world, where companies work to use advanced data analytics in finding those moments in which the activity of their competitors on social media platforms is low and then capitalize on those moments [2].

From this analysis, it is possible to identify a few concrete recommendations that an advertising manager might actually follow in an effort to optimize a timing strategy. This path to success begins with observing competitor timing patterns for potentially revealing openings through which one can effectively differentially position a brand in the marketplace. The traditional appeal of large audience sizes versus the intensity of competition in those time slots can often lead a manager to conclude that less competitive periods may yield better overall returns. This, in turn, needs the elaboration of flexible timing strategies able to respond with a sharp twist to changes in competitors' behavior. Thereafter, sophisticated data analytics should be made use of to unmask those underused time slots which may yield a better return on investment despite probably smaller audience sizes [2]. In sum, these practices form a comprehensive approach to strategic timing in advertising-a way of balancing theoretical insights with practical market realities.

Game theory provides a vehicle for examining the strategic dynamics of advertisement timing. The analysis in this paper strongly suggests that, in many circumstances, firms can do better by taking competitors into account and seeking timing strategies that trade audience's reach against competitive intensity. The Nash equilibrium thus detected suggests that companies may be inherently pulled towards timing patterns that avoid direct competition, absent of any overt coordination.

While this analysis has several valuable insights, several limitations should be noted:

1. Real-world advertising markets may be too richly detailed to be usefully approximated by this two-player, two-strategy model.

2. The assumption of fixed advertising budgets is somewhat artificial and does not accurately model the way marketing resources are allocated.

3. The model does not consider, for instance, issues of audience segmentation or platform-specific timing.

The limitation notwithstanding, the game-theoretic framework here provides the basic vertices on which a brilliant comprehension and optimization of advertisement timing decisions stand in competitive markets.

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## ЗАСТОСУВАННЯ СИСТЕМИ РЕКОМЕНДАЦІЙ У ОНЛАЙН-МАГАЗИНІ

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Зі стрімким розвитком електронної комерції зростає конкуренція між онлайн-магазинами, що змушує їх шукати інноваційні способи утримання клієнтів та збільшення продажів. Одним із таких способів є впровадження систем рекомендацій. Рекомендаційні системи не лише допомагають споживачам швидше знаходити потрібні товари, але й персоналізують взаємодію клієнта з платформою. Успіх гігантів, як-от Amazon чи Netflix, значною мірою пов'язаний із використанням цих технологій.

Система рекомендацій базується на аналізі великих обсягів даних про користувачів, товари та їхню взаємодію. Для цього використовуються такі методи: