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FILLING THE GAP BETWEEN LOB ACTIVITIES

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ملخص البحث:

تشهد مصر هذه الأيام تنفيذ العديد من المشروعات القومية والتي تندرج تحت مظلة المشروعات التكرارية. أجبرت الضرورة الكثير من المشروعات القومية عمل برامج زمنية دقيقة بأقل تكلفة ممكنة لوجود ازمة اقتصادية خانقة. بعد دراسة اشهر الطرق لعمل المخططات الزمنية للمشروعات التكرارية وهي طريقة خط التوازن (Line Of Balance)وجدت فراغات زمنية بين الأنشطة.

كان الهدف من هذا البحث هو كيفية الاستفادة من هذه الفرغات في زيادة مدة تنفيذ بعض الوحدات داخل النشاط الواحد بدون تأثير علي زمن المشروع الاجمالي مما ينتج عنه تأخير بعض الالتزامات المالية مما يعطي اريحية في التدفقات المالية للمشروع.

استخدمت الرسالة طريقة تعدد الإنتاجية للنشاط الواحد وهي استخدام اطقم عمل ذات إنتاجية مختلفة داخل النشاط محل الدراسة دون الاخلال من قواعد طريقة التوازن في تحرك اطقم العمل من موقع الي اخر دون تعارض. وهذه الطريقة تؤدي الي وجود اختلافات في مدة تنفيذ الوحدات داخل النشاط محل الدراسة مما يساعد على ملاء الفراغات الموجودة بين هذا النشاط والنشاطات التي تليه دون التأثير على الزمن الكلي للمشروع.

تم تصميم البرنامج ليقوم بعمل جدول زمني كامل للمشروع بداية من الجدول الزمني للوحدة الاولي الي ملئ الفراغات بين الأنشطة. يعمل البرنامج على اربعة مراحل تبدأ بمرحلة عمل جدول زمني للوحدة الاولي ثم مرحلة عمل جدول زمني للمشروع بناءا علي الزمن الكلي المسموح به لتنفيذ المشروع ثم مرحلة حسابات الفراغ الموجود بين الأنشطة محل الدراسة وأخيرا مرحلة ملء هذا الفراغ باستخدام طريقة تعدد الإنتاجية. يقوم البرنامج بعمل مقارنة للمصروفات عن طريق رسم بياني توضيحي للمصروفات داخل النشاط محل الدراسة قبل وبعد ملء الفراغ.

نوصي بعمل دراسات مستقبلية في استخدام طريقة الإنتاجية علي جميع أنشطة المشروع لدراسة تأثيرها علي زمن المشروع.

ABSTRACT:

This paper presents a new solution to decrease the cash out flow in planning a repetitive project. The widely used technique in planning a repetitive project is Line of balance (LOB). Gap between LOB activities can be found when production rate of activities varying between each other. This gap can be used to decrease the cash out flow. The proposed model easy planning a repetitive project with LOB graph. It is respect LOB continuity rule and meets project time constrains. It is employed varying crew productivity (VCP) to filling the gap between LOB activities. The model meets project time constrains.

Keywords: Construction management, Cost control, Varying productivity, Scheduling

INTRODUCTION:

Economic Problem in Egypt makes a negative effect on national project funding. The Egyptian law (89-law) status that no excuse for project delay resulting from delays in project funding. That's leads to the need of excellent Management. Therefore, Engineering Management (EM) can be the perfect solution. EM can be defined as a career that brings together the technological problem solving of engineering and the organizational, administrative, and planning abilities of management to oversee complex enterprises from conception to completion.

A large portion of construction projects fall into the category of linear or repetitive, and it is necessary to plan them both accurately and optimally. Objectives may require several crews with diverse skills to be completed and crews need to schedule to ensure an efficient output and adequate control. Several methods have developed since the early 1970s to address the features of repetitive projects.

SCHEDULING A REPETITIVE PROCESS:

One common variation is the Line of Balance (LOB) method, which allows the balancing of operations such that each activity is continuously performing from one unit to the other. The major benefit of the LOB methodology is that it provides production rate and duration information in the form of an easily interpreted graphic format (Hegazy And Wassef, 2001).

Line of Balance (LOB) and its variations are developed to search for a better solution for repetitive projects such as tunnel construction, high-rise building, pipe line projects, and even utility projects. Arditti (1986) states that main object of scheduling a process may be: 1. A programmed rate of completed units is met. 2. A constant rate of repetitive work is maintained. 3. Labor and plant move through the project in a continuous manner such that a balanced repetitive labor force is maintained and kept fully employed. 4. The cost benefits of repetitive working are achieved.

GAP BETWEEN ACTIVITIES:

Gap between activities can be found when production rate of activities varying between each other. From fig.1 the gap can be defined as the time variance between ST of activity B and FT of activity A. By analyzing fig. 1 activity A has a production rate > activity B production rate. The gap can be found in this case because of varying production rate between activity A and activity B. As a result of mathematical calculation FT of activity A can be decimal number. In real work time cannot be fractional number. From that the ST and FT of any unit of a certain activity should be round up to zero decimal without changing the LOB procedures. To achieve that a step analysis should be performed.

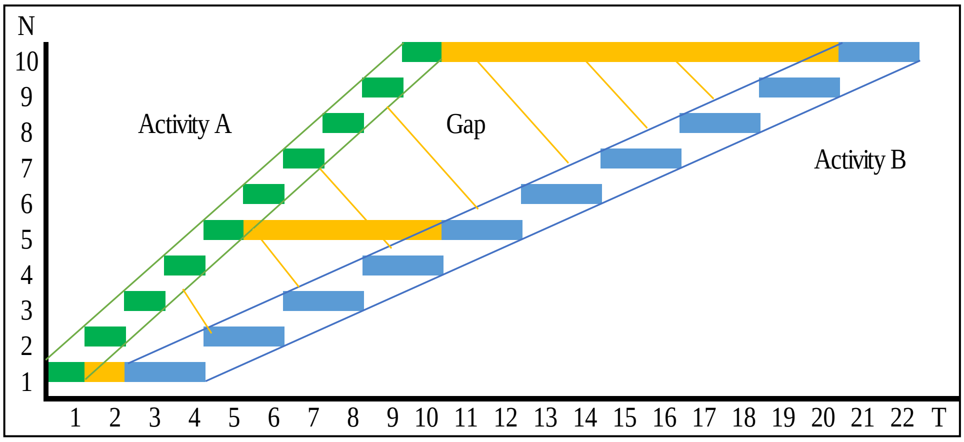

Fig. 1. Gap between activities

STEP ANALYSIS:

Hegazy et al, 2004, stats the possible arrangement of crews to achieve the work continuity. He divided it to five categories which are Parallel Crews, Staggered Crews, Crew Moving, Interruption, Different Duration.This model shall use Staggered Crews, in which the crews shall moves in a continuous manner and without any interruption. In this case the crew number 2 (C2) shall start after crew number 1 (C1) start time. The duration between C1 ST and C2 ST can be defined as step. From that the step is the duration between ST of certain unit and ST of its successor unit. Fig. 2 describes the step duration.

The Step Duration (S) = D1/2 …….(1)   Where, S = Step Duration, D1 = Activity first unit duration. Example (1) if an activity A with a duration of 4 days and with 2 crews the step duration can be calculated as follow: S_A= 4/2 = 2 days. In case of activity A needs 3 crews to complete the work in this case the equation can be as follow:

$S_i = D_{1i} / C_{ai}$ ……..(2)   Where, S_i = Step Duration of an activity *i*. D_{1i} = Activity first unit duration of an activity *i*. C_{ai} = Number of crews of an activity *i*. As in example (1) if activity A needs 3 crews to finish the work the step duration calculate as follow: S_A = 4 / 3 =1.33 days.

In real work time cannot be < one unit time. S should be rounded down or up without decreasing or increasing the total duration of the activity. This procedure should not change the LOB procedures. So Equation (3) can be the best solution as follow.

$S_i = S_{i1}$, …., n_1 S_{i1} , S_{i2} , …, n_2 S_{i2} ……...(3)   Where, S_i = Step Duration of an activity *i*. S_{i1} = Round down (S_i), S_{i2} = Round up (S_i), n_1 = number of repeated S_{i1} as in equation (4), n_2 = number of repeated S_{i2} as in equation (3).

$n_2 = (S_i - S_{i1}) * C_{ai}$ ……..(4), $n_1 = C_{ai} - n_2$ ……..(5)

As in example (1) if activity A needs 3 crews to finish the work the step duration calculate as follow: S_A = 4 / 3 =1.33 days, S_{A1} = round down (1.33) = 1 days, S_{A2} = round up (1.33) = 2 days, n_2 = (1.33 - 1) * 3 = 1 time, n_1 = 3 – 1 = 2 times, for repeated unites = 5 unites. From this calculations step analysis are as in table (4-11) and figure (4-12).

Table (1) Example (1) Step Analysis

Unit	1	2	3	4	5
Step	1	1	2	1	

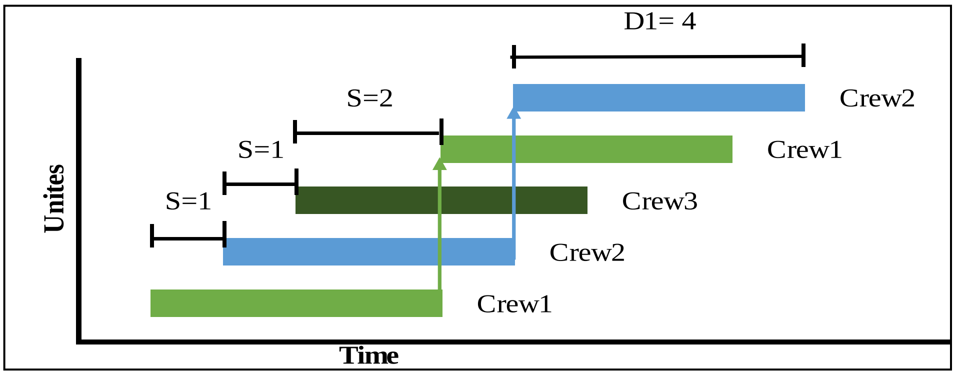

Fig. 2. Example (1) Step Analysis

VARY CREW PRODUCTIVITY (VCP):

In many cases production rates between LOB activities are different between each other’s. This different production rate case a gap between those activities. If this gap can be filled without any change in LOB rules to decrease the negative cash flow, this can be a helpful solution. The best solution for filling this gap, can be VCP in one activity. This solution can be helpful in two conditions. The first condition is the production rate of the selected activity is larger than its successor activities. And the second condition is this activity hiring more than one crew to finish this activity.

In those cases, as shown in fig. 3 crew number 2 can be decreased in production rate to filling the gap between activity A and B. This decrease in production rate influences activity duration. The decrease in production rate increases activity duration.

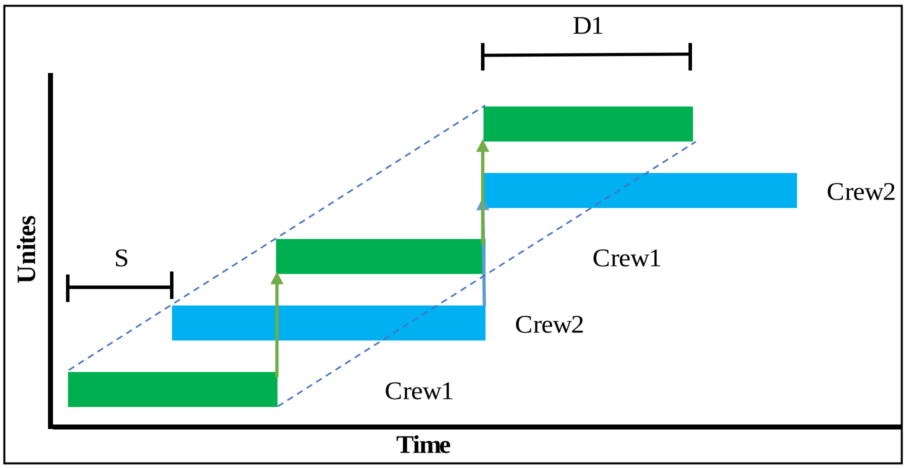

Fig. 3. VCP in one activity

This increase in duration should be within range of gap ST & FT, to avoid increase in total activity FT. The VCP process can be divided into three stages. Stage one is to allocation crews to unites. In this stage, the model shall use staggered crew arrangement to provide a crew allocation in unites. Stage two is to find the TF of the finish unit for each crew. This process can be made be the model as shown in fig. 4 and 5 using equation (6).

TFin = STjn - FTicn ……..(6) Where, TF = Total float for activity i in unit n, FTicn = Finish time of activity i for crew number c and unit number n, STjn = Start time of activity j in unit n. As in fig. 2 example (2) if FT for activity i in unit 4 = 5 days and ST for activity j in unit 4 = 8 days, TF can be = 8 - 5 = 3 days.

Stage three is to find the available added duration (D*add*), which can be added to the original duration without any disturbance in LOB scheduling. D*add* can be calculated as in equation (7). D*add* = Round down (TFin / Cai) ……..(7) Where, D*add* = Added duration, Cai = Number of crew for activity i.

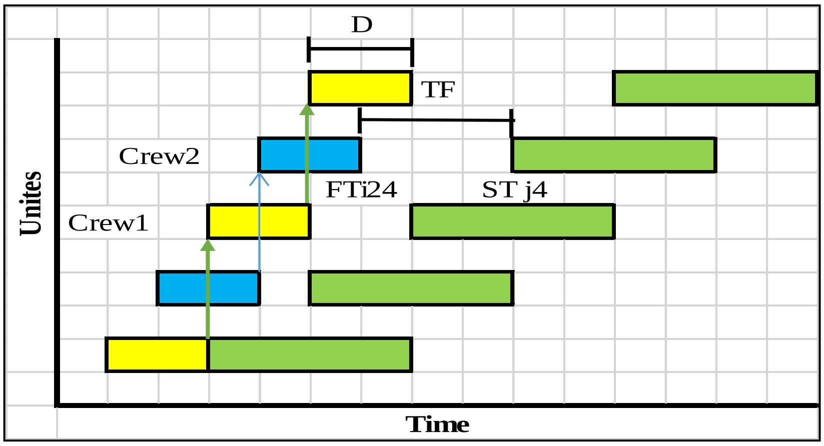

Fig. 4. TF Calculation

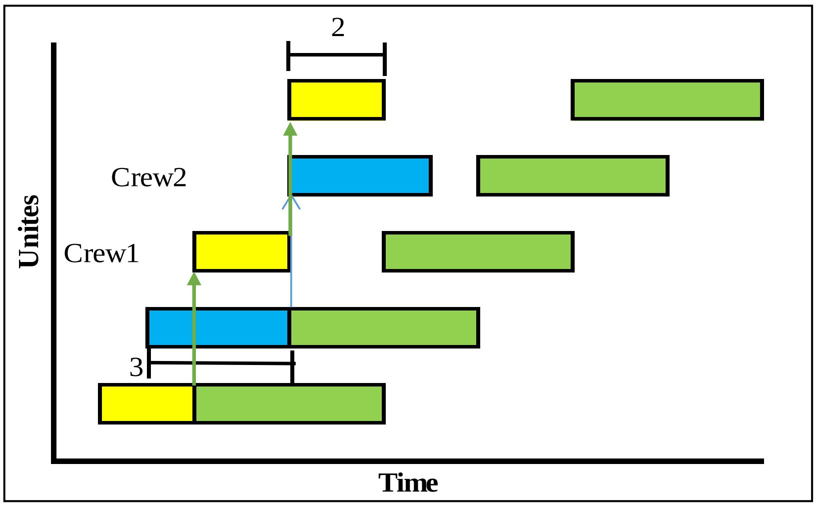

Fig. 5. Example (2) VCP Calculation

As in example (2), D*add* = Round down (3/2) = 1 days. Fig. 4 shows the new duration of crew 2 in activity i.

MODEL DEVELOPMENT:

The model divided into four stages. Stage one Scheduling first unit. Stage two Scheduling repetitive project. Stage Three gap calculation. Stage Four filling the gap. **Stage One:** The input data of stage one is the first unit activity data of the project and its relationships. The data output of stage two, which is ST and FT of each activity and total duration of the first unit (T1). **Stage Two:** The input data of stage two are number of unites (N) and total project time (Tp). The output data are activities number of crews, activities relations and LOB graph. **Stage Three:** The input data are the selected activity and its processors and successors activities. The output data are the gab ST and FT, activity step and cash out flow for the selected activity. **Stage Four:** In this stage, the model aims to reduce the selected activity by using VCP. The output data is the new activity step and cash out comparison.

VALIDATION:

The model can be validated in common repetitive project in Egypt. Two case study can be used to validate the model. The most essential project is social housing. One million unites needs to be construct in Egypt. This unites Should be construct in three years. So that the first case study (Case A) should be in a social housing project. The Egyptian government have a special attention to the youth. The ministry of sport and youth construct 1500 football playground yearly youth center allover the country. So that the second case study (Case B) is constructing football playground.

Case A: By entering the project data to the model as discussed, fig. 6 shows the output data of stages one and two. Fig. 7 shows the influence of using VCP on cash out flow for activity B.

Result: Activity B Duration increased by 25 days and the cash out flow was reduced in the old FT which is day 179 in project time with 578,125 L.E. If the interest rate = 19.75% the total cost can be decreased by 125,128 L.E.

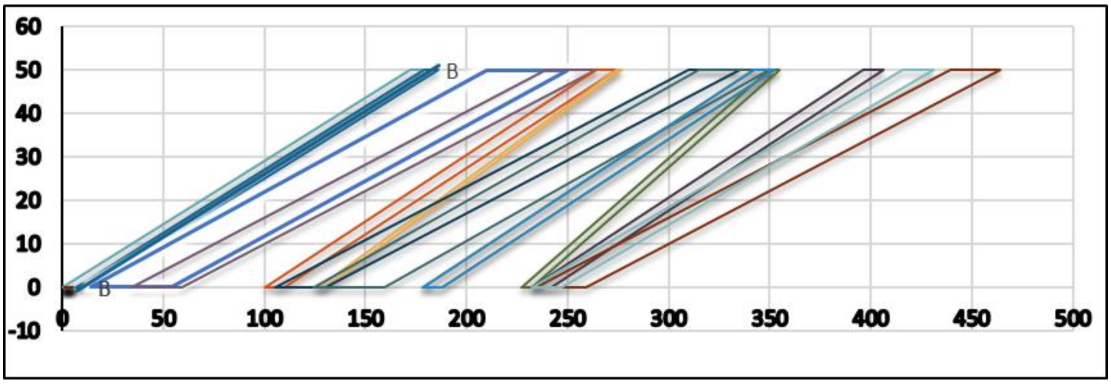

Fig. 6. Case A - LOB Scheduling

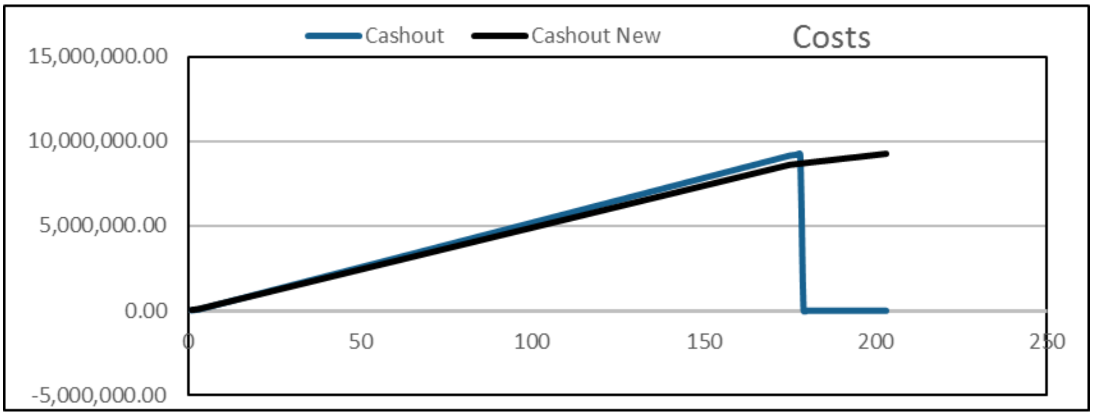

Fig. 7. Case A – Cash out Comparison

Case B: By entering the project data to the model as discussed, fig. 8 shows the output data of stages one and two. Fig. 9 shows the influence of using VCP on cash out flow for activity D.

Result: Activity B Duration increased by 25 days and the cash out flow was reduced in the old FT which is day 10 in project time with 327,272 L.E. If the interest rate = 19.75% the total cost can be decreased by 38,959 L.E.

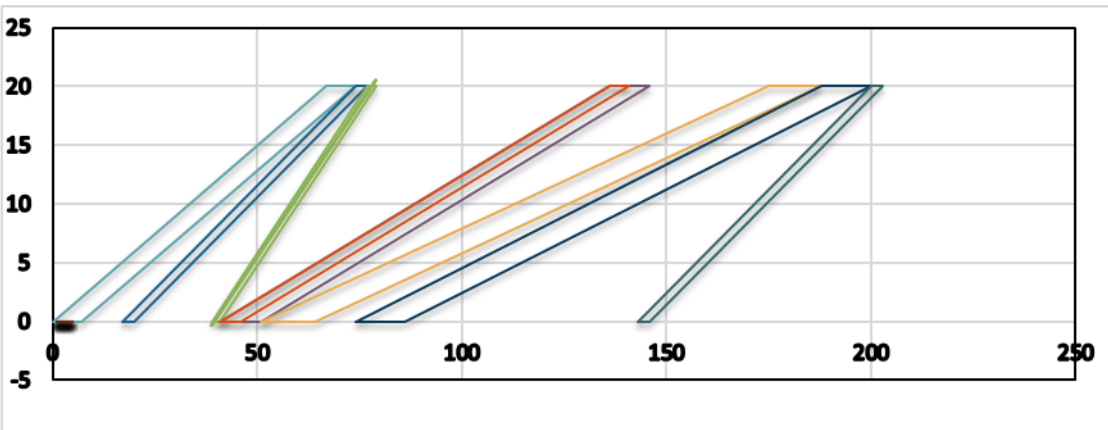

Fig. 8. Case B - LOB Scheduling

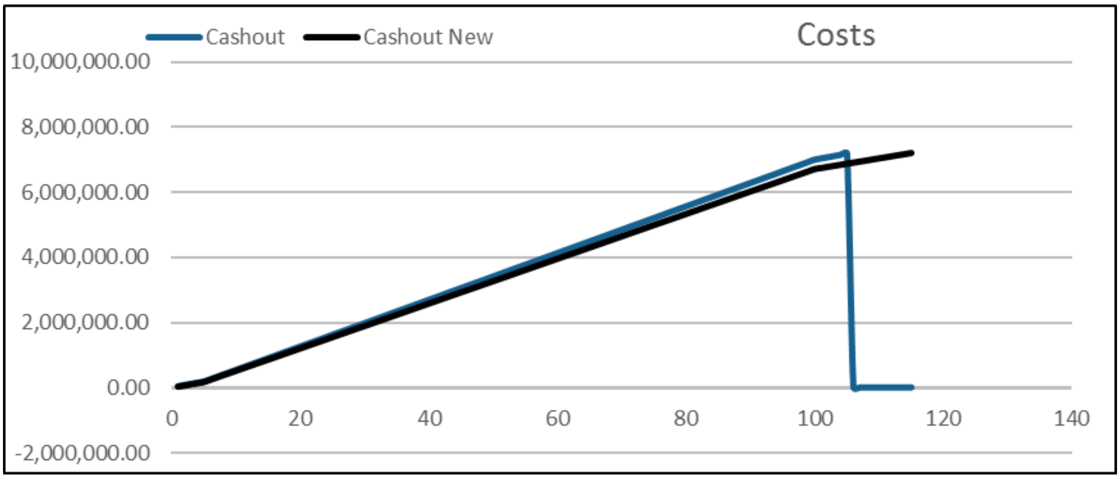

Fig. 9. Case B – Cash out Comparison

CONCLUSION AND RECOMMENDATION:

This paper presents the VCP system used to filling the gap between LOB activates. The proposed model can easy scheduling repetitive activities using integration of CBM and LOB technique. The model can delay cash out of a certain activity without affecting the project duration. The model can delay one activity in every trial. Its can compare the cash out of one activity only neglecting the effect of indirect cost. Despite the ability of the developed model to generate a delay in cash out, the model can be enhanced by adding the following features:

1. Discuss the effect of delaying multiple activities on project duration and activates relations.
2. Analyses the effect of delaying activities on project cashflow.
3. Develop a formula for using VCP in multiple activates and different relationships.
4. Study the influence of indirect cost on cash flow.

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