### algorithm\_week2\_1-20240909

说话人1 00:00  
The will be very good for sleep. Ii just want to make sure this sample allow me to see any danger that this will make you sleepy. Raise your hand. No, that's good. And then, second, I know that many of you come from different backgrounds, some of you from computer science of engineering, cyber security, but there are also some of you who come from other majors, like architecture. Yeah, I also thought about mechanical engineering, for example. So just want to remind you, if you are not from computer science related subjects, I believe you will also study very well, but you need to spend extra time making up for some missing courses that should have happened. The undergraduate.

Actually, we did some interview for those who were not from computer science major, and some of you are very ambitious and some of you have already learned by somebody. Else are also the machine many models by themselves which are good, but for some courses probably need to make extra preparation for certain missing components.

Okay, so I hope you are prepared for that. All right, because you will be competing with the classmates from computer science, right? I hope that you will be in the starting at the same place, not like this. Please make use of your spare time to make out some missing subjects.

And then let me see. So I still have some time to say something right. Now, ii guess you already noticed that this course code is a bit different from other courses you are taking this semester. What's the difference? You already took four courses already right in the week? This is the last one, although this one is supposed to be the first one. But this one is opening ceremony. So that's why we do it now. Right? So what's the difference? Very good. It starts on six. So now the, well, the implication of this stuff with six. What does it mean? Basically, very good, very difficult, very good guess. So 56, right? Six, high and five. So definitely, the requirement of the post 76 will be more challenging compared to five. So don't blame me if i'm making more difficult compared to your other four courses. Okay, but at the end of the course, I will also do some a survey, all right, to see whether you feel it's indeed more difficult than the other four courses.

Okay? Yeah, now I guess we can start now. The course title is called algorithm analysis and gates there. What does it mean? It means that we've got two components. One is algorithm analysis, or remember, this analysis is not designed ok because for those who are in a computer science major on the breast study, there are some error reports, right? So you need to design some algorithms. But here we put a less focus on design. We put more focus on analysis, meaning how to persuade people that you have with them is good.

Then game theory is game theory. It's very popular, but it's not me, right? Because it has nothing to do with the traditional video games, right? But it has something to do with other types of games like chess, or some other, some other games, which are more high level. All right, not like the ordinary games. Here's the schedule of the two parts. The first part is review of the classic elements, which is today for this one. By the way, I think that the court, the class structure is a bit strange, because for those sitting here, you'll be looking at that. Right? And so anyway, I hope i'm not dropping your view, because usually I i'd like to stand here, and then you cannot see it free at. All right? So it seems that it's better for me to stay here instead of into the front.

Now, the review will basically cover some traditional, very well known algorithms, including greedy algorithm, dynamic programming, and also divide and conquer. As I said earlier, some of you may have never heard about these things. Don't worry. I hope that my explanation will make those who are even don't have any foundation and so far.

And then next, we will be talking about approximation algorithm, which means that we want to design some algorithms which have a good performance compared to the optimal solution. Ok this good performance is provable, which means you can prove it is good. It's not actually running experiments. Or after running these experiments, I found that the output is very good, not like that. We are using mathematical proofs. This is all my approximation efforts. And then next topic, week three will be online algorithms, which focus on the scenario where the input comes on level. All right. You do not know the future. You only know the current status, and then you need to make a decision, by the way. And then afterwards, you want to see more input, you cannot revoke your earlier decision. You have to stick to the earlier decision for earlier items. So this is all my area.

Then finally, we'll talk about some other topics. If we have time, including randomized algorithms, streaming algorithms, and also a special kind of analysis for any more time analysis. This is the part one algorithm and algorithm analysis. Now, part two will be game theory. Then we'll talk about game theory basis, including the equilibrium for different types of games. And then after that, we'll talk about cooperative game where people work together to achieve the goal. All right? And then next will be mechanism design, which means people do not work together, they will compete with each other. Their interest somehow competent with each other. So there is no collaboration. Then here we are using four scenarios to illustrate how to design mechanisms, including option, maintain, and also facilitation games, fair division, and finally scheduling problems.

These are the materials will cover in this semester. And actually, ii believe that you already noticed, we put all the slide on canvas, which is different from the main campus. But one thing on the bedroom, I remind you, better, you'd better not review any slides before the lecture, because if you review the slides, you probably will gain less the lecture, because too much.

So better review this night after that. This is my philosophy. Right? Don't need to do preview, but reviews. Okay. So next slide, I hope you didn't see this slide yet. Anyone see the slide before? No, no, good. So what do you think? I will put it on the next slide? All right, this purchase. How come this was? I only put it here, right? What's the next time? Not only assessment, very good, ok yeah, so something like that, right? You need to know how can you get a grade in this course, right? We need to have assessment. And here is assessment.

The first part is called in class exercise. What is that? It means that in the lecture time, I will randomly or sometimes purposely raise some questions which you should answer. And that's a bit, okay, but we do not care about how accurate or how correct your answer is. What we care about is whether you record it, right? Question. Okay. Second, whether you answer makes sense, we are not checking whether your answer is correct. We are checking whether your answer makes sense.

Yeah. Now this is the first part, and it is split into two components. First half of the semester will be part one exercise in class exercise. The second half of semester will be part two in class exercise. And we will post the assess assignment detail whether time comes, for example, in week five, maybe I will post the first part of the class exercise. And then you can submit 5 weeks seven, and then the second one is seven. All right? Then each of them will be worth 5 % of the total grade. Okay? So to the brain is right, it means that out of the 100 %, each in class exercise is worth % 5 %.

Now second, second is bonus. What is bonus is that sometimes I ask questions in the class and for those who answer the question, raise your hand answer question correctly, and then you will get bonus. Every question is 1 % bonus. All right. Now some questions are easy. Some questions are challenging, and some questions are explicit, which means I will tell you the smallest question. But some questions are implicit, which means what I wanna tell you this for this question. But afterwards, after you answer correctly, I will tell you how to support this question. So that means you need to be serious about every question I raised in the lecture. Then everyone has a ceiling of this bonus, which is 5 %. In other words, everyone can only get 5 % bonus throughout the semester. After get five, I have to apologize that you no longer are qualified to raise your hand and ask a question in class. Although it's a somewhat not fair, but because it's a ceiling, so we need to give everyone chances.

So you can still write an answer in the script or paper and give to me during the break. It's still allowed, but it will somehow lose the the possibility of raise hand and answer the question. I will let you know when you skip the ceiling. All right, no worry. I will keep track of that. And then we have assignment. We have put together three assignments. There will be a release in week four, week seven, and week ten. Each of them will have a 3 weeks duration before you submit the assignment. Okay? And then some questions they are just standard exercises of the knowledge there. Right? Some questions would be difficult. For example, I may ask you to prove some theories in papers. Please prove 05 in that paper. Then you can say it's too simple. I just go to that paper. The paper must have a proof of that theorem. I just copy that proof to my assignment. You can do that, but usually the paper I I selected, they have no zero, no proof of that zero.

You have no way to find it on the internet. That's why you need to use your knowledge about understanding of the paper, and then try to prove that theorem from scratch or from the existing of us in the paper ok so you need to use the existing sentence to prove the result in that paper ok because usually for conference, you have aa limited space. So some proofs will be admitted by the authors. So we are targeting at those theorem. And also, before now, ii believe many students are very smart, because ii have been doing this for quite some years and have seen some very smart students who go out to try to final proof in some other way.

Now, it's not a good session, but there is a question. So can you think of some way where you can find the proof? You cannot find the paper check pd a it's okay way. But for those proofs, somehow the machine, the gpp may not be that smart. And on the other hand, probably in this offering, we do not need to use check gpp for the moment, but for future courses, probability use it. But trust me for this course. Did we don't need to actually, we are not checking on language writing, et cetera. So most of the logical reasoning, so very unlikely to check to be healthy, but a it's a better point for sure, right?

So any other not so ethical ways that in the university, we are supposed to teach students to behave ethical, right? But if we do not say something, then some students may think of some way which are not ethical. All right? And also maybe you can find some way that I it's not so easy for me to find out. You get some trick. No worry. I will not blame you. If you tell me that unethical approach, it's just a brainstorming session. No, good news. But still, I am going to tell you that unethical way, but I i'm also going to tell you that was some work.

All right. So they don't ethical way. Something like several years ago, my student received an email from a student taking my course, right? That student asked my student. I'm very curious about this paper. Do you have a full version of paper where the proof is shown? Okay. And then my students right away tell me for me is that student taking a course, I say, obvious this impeccable way, but do not try it because i'm going to pick my own paper or my friend's paper. So they will realize that so do not try to contact the authors that does not work. Okay? So much about the assignment. And then we come to quiz. Chris will take a 15 %, and it will take place in week nine, but very likely it could be week ten, too.

So I remember it's a november 4th, immediately ten. I am not very sure. Can you check the panel? November 4th, which week is it in? Is it 911? It's nine. I didn't realize that very nice, ok november the 4th. Right? We tried to do it on the member of the force. The exam

说话人2 16:43  
different case.

说话人1 16:46  
Again, it depends on how progress, because although I had a determined schedule contents to cover, we may meet with some special situation where I the goal is slower. So that will also postpone the midterm, but don't worry. Since you're here, you will not miss the information.

So. Yes. Now final exam will be 60 %, and very likely it will take place in the there's only one exam each week, so it will take place in delhi. Right? Which day? I don't know, you will see it very soon in, not very soon in the end of october. I like it. So any question about the assessment? No. Good. So now we'll go to the next one. Now, ii have one question about your other course. All right. You have a machine learning course. What does the lecture say? Is that machinery course, more theoretical or more practical? Right? There you go. Then this one will be similar to that loss. This one will be pure variable. Okay. Don't worry, because there it does not mean it's bad. Sometimes it's easier. So let's start with the review of the evidence.

And so now i'm pretending you do not know it. Then there are some well established classes of algorithms. We start with this very famous thing called enumeration. So I believe everyone knows this work enumeration, right? Okay? Just try everything, right? Find the best. So it's a very easy error. But sometimes you need aa little bit more thinking in order to find a good solution, which uses enumeration.

What does it mean? Let me show you one example here. In this example, it says that you have many roles of coins, so they are very rich and many points, right? I is it maybe $10,000, right? We have many roles. Then these not 10,000 rows. They also consist of 9 columns. Basically, it's a two d right? Imagine the two d array, many rules, but only a few columns, only 9 columns. All right. They know every coin has two sides, heads up and tails up. Right? So head up, which side is head? This is head up, and this is tail. So you have two sides. And then at the very beginning, every coin has its face, it has its direction, either tail up or head up.

Now, your goal is to flip something such that the number of heads up is as many as possible, which means if you can make every coin heads up, then definitely, that's the best solution, because everyone is heads up, right? But sometimes you cannot make it. You may ask me why I cannot make it. I just look every point. Right? And then I just deal with every . and then make it catch up. Then I iii achieve the best status, but the problem is you cannot flip every coin. You can only flip a single whole row, all of the common, right? These are the only operations you can do. So.

Now, question, then how can you get to a status where there are as many heads up as possible? Do you have a question about what you can do in your home? Is it there input? What you can do be your goal, right? If it's clear, i'll give you 2 minutes. You can discuss among yourselves. Try to find us on us a solution you can follow in the following. There is no probability that 66. So basically, I tell you every line at the very beginning of what's the status? I will tell you this there is no problem. I think that's the only function we need to sign up. So how do you make sense? You need to make a commission made here are made in transition for us.

It's time to start the first solution. Right? Now, the first solution is also not trivial, because first of all, you need to figure out how are you fit, or how many times that each role in each column at the very beginning to narrow down the searching space to what to how many times need to get a low or column. For example, this is $1 brand, and cross means not good. K one ok certainly is a pattern. So this is see this one. There are six has a 3 pairs of math.

Now, my first question is, how many times do you need to flip aa certain role? Do you need to flip it? 3 times, 4 times, 5 times? No. Right? Why not a is it? 2 times? It means one. We have. Yeah, it just to be nothing. I didn't do anything for it once. And then 22 times. They just come back to your the original state, right? 2 times does not make sense. And it's similar for 3 times 4 times. They do not make sense, right? For each single row or a single column, you only need to flip once. Or you do not flip it, right? You either flip or do not flip.

So basically, it means that for each such role, you only have two choices. It's a 01 choice. Zero means, what do not? Flip it, right? One means flip it once, but if it was ok so each rule of each column only has two choices. Then what's the easiest method? Or at first method, you will think of to find the best solution relation? Just try everything. Try every possibility, right? Ok so how many possibilities are there? Thank you. Every role has two choices, right? I get 01, and then two to the 12 to that 102 over nn very good. This is for all right. It was a column, right? Columns 1999. Good. So this is the total number of combinations, right? You or everything in china.

So for each of them, you need to do something, right? You not only try this flipping strategy. You also need to try to do that. How do you decide? I think, first of all, do not acceptable in central, et cetera. You decide a lot of the strategy, right? You need to see how good the solution is, right? How to see how good the solution is. You did what car. You can check that you can check the requirement. How do you do this that they need to check every point? It has up or tail up, right? So that means you need an extra time of the total number of points, right? Each coin you need to check. So total number of coin will be nine. And right? Okay. This is the total running time. You need by doing this kind of enumeration, right? So this indeed enumeration, because you try all the possibility, right?

Among all these solutions, you take the vessel, right? 31, maybe 100 a has a strategy to That has a just try everything and take the best part, right? The largest count of heads up that solution is your final solution.

Now, any questions about this simplest method? I believe no one has a question, right? It just tries, but it's too. So it's two to the n and confusion, even at two to the n is exponential is not good. That computer science, the exponential income, usually it will not use, right? Ok so the total improvement, how many? Osrsr is? The is it in this role that there is more than ten? If limited? All good. So this is a very good improvement. So basically, I do not do some kind of enumeration of all. Instead, i'm be or be be a bit smarter and say, for example, this role, right? This role has six skills as six heads up, right? Then I will not flip it, because flipping makes myself worse, right? Okay? Now, on the other hand, it has more tails up as what you just said, right? And then I was looking back.

Now, there's a very natural algorithm that would just check role after role to see whether I should flip it or not. Right? Okay, after I check all the rules, would you? Check? I check, follows, right? Okay. They aren't all check all the ￡9. What do you do? Check roof. Very good, because i'm thinking that you can say then I should stop, right? As I should come. Remember, after you check your columns, some column will flip, which will make some of your roles worse, right? And then you may need to flip them again. That means after checking rows and columns, you need to check rows and columns again, right? And then check rows and columns again when you start. So not being changed. Yeah, nothing changes, right? So if you check all the roles in front of them, nobody should be split. And they check all the problems. They also know they should be flipped. They stop, right? So this is a reasonable time to stop this area, right? It is not true. Ok no input. Let's see. What's the running time into the problem? Running time is a bit challenging here, because you just need to know how many times you check all the rules and all the contract we call one such checking as one round.

The important thing is to figure out how many rounds are needed, right?

How many rounds are needed. Some information, for example, in one round, at least increase the header by how much? 11, right? A a it's a worse case, right? We checked every role we found, but one role will make many messages better, right?

Anyway. And then flip all the columns, try to check all the columns. I found nothing can be.

So basically, at least, you can improve your heads up by one in terms of cats, right? One more heads up. Right? And then altogether, you have 9 points, right? So that means very likely you probably be nine n rounds, right? Because every round only in 2 × 1, but this is a very, very pessimistic analysis. Why do I say that? Because it if you want to really achieve nine n rounds, what does it mean? The beginning series, what? All tales, but the beginning stages, all tales. How many runs do you need? Nine. I'm not right. What about equal to all hands up? Right? So it doesn't make sense, right? But remember, we are doing some kind of very pessimistic, conservative analysis, sok it was this right? Every round. I think we put that one.

And then the largest count I ever increase is my end, right? So I have so many rounds. And each round I need some time, right? Each round you check all the roles and check all the problems, right? So what's the time? 1 plus ten, nine plus ok very good, ok so this is nine n plus nine n right? Row and column. Now, there are some details here. I'm not going into details, but that roughly, the running time is this much, right? And right times and right, it's roughly answered, right? Roughly answer is quadratic time. Now, now that's the ones question. Can we stop? Now? We have that's an algorithm.

This algorithm runs in n square one, Done better than the first one. Any suggestion? By the way, anyone who gets bonus will write out the name of this design during the break. Okay? Any objection to my argument? I say that we found a better area this amazon will run the answer on. So remember, in any class, you need to be able to challenge the, yes. Especially this one, you need to think about what is an algorithm. Maybe you are missing some component here. I told you how much time it needs. Right? But maybe I forgot to tell you something. What did I forget to tell? That's cool. But memory, ok memory, we also analyze. That's true. But that's not the memory is similar as time. It's the same dimension, a similar dimension. See? This is, I think you should check the one. Or when you go, if the role is all fails, you can that is yeah. That this moment really did, right?

So in all these maps, right? When you have such a role, I already flipped it. I will not miss it, right? I I we can do it for this. Are you want you to say you can speed up this? That's good by doing some pre processing time.

You can do that, but it's still not the

说话人2 33:46  
most critical

说话人1 33:47  
thing. In the second hour. You haven't proved it. Correct. Very good, by the way, sorry, this time it's okay. You know what I mean, right? Okay. Basically an algorithm, it should offer the correct answer. Did I show you people out the grounds? No. So even though ii tell you very, so are the right time is very good? It's only aspect, but I didn't tell you, it can help the correct answer. And actually, i'm going to tell you that it cannot produce the curve. Right? Answer. Why? You may say it's pretty straightforward, right? I keep improving until it can no longer improve. Then I stop what's wrong with it. I I didn't see that the problem. And at this moment, you may recall what you learn in your under arrest. Okay. What should I do? Is achieving some autumn search. What kind of autumn? How many of you have learned in the some heuristic in university like the second gradient, grading descent method or something like that.

But anyway, there's that kind of you have some kind of curve. I'm going to find the smallest number, and then a smallest or smallest value play. You just go along the curve in the direction of decreasing value. For example, you have a cable like this, right? I'm going to find the smallest value. And probably you got here. Ii go this direction, because that direction decreased the value, right? Decrease the value ok what's wrong with this method? It may be the woman.

说话人2 36:04  
You may

说话人1 36:05  
get the romance

说话人2 36:06  
and

说话人1 36:06  
we get the wrong answer. And that wrong answer. We call it local medical right?

Since similar same here. In our conflict examples, you are doing improvement every time, right? But your improvement is based on certainly one row or one part, right? So this is also a kind of local improvement. It cannot give you the right answer, always. Why. Now it's time for you to tell me why you cannot always give you the right answer. Yes. I know the answer. So why can I do that? So in other words, let me rephrase my question. So if you can no longer improve the solution by flipping 1 row or flipping 1 column, can you still improve the solution? If then how seems to still to be a variable if the components question?

Okay. One role, not good. One column on it, but I still like

说话人2 37:46  
311. And then before

说话人1 38:00  
your

说话人2 38:01  
metrics.

说话人1 38:02  
So basically, if it can flip a combination of role in parts to improve, for example, what I draw here, what does it mean?

说话人2 38:09  
Such as you have seen, face off and gives up in a comment or in a row. But you turn on finish proponent, then the get on the face becomes a tail and you. But is that corner or that? So means the beautiful parents, although there are more kids.

说话人1 38:33  
So give me one example, right? And then actually this will be you want to exercise at least for your thinking during the break too. So can you find can everyone that you find an example where certain multiple roles and bonds together can improve, but flipping any single rule or single part cannot improve the solution?

Okay? Basically, it's a bubble. Your actual space, right? If you flip one single rule of one single problem, this is a restricted action. Then what general action will be flipping multiple rows in multiple columns. And a special piece of this is flipping 2 rows, 2 columns, right? Very likely to find an example there. Right? Ok from this example, that an algorithm you need to show it is correct. And then you analyze the running time of the algorithm, right? Our first attempt to improve this element face. This one does not work, although it's many times good, right? So now let's go to our final. We want to find the correct algorithm. What can we do? Well, now, because this question comes from a program competition, and then usually for program competition, the problem setup will make the parameters of the problem of this special, such as it is solved.

So what's special feature you see in this problem destruction? Very good. Nine. Why 9 columns? Why this problem is not about n columns? The answer is easy, because it is n columns. Cannot solve it. We only saw it from 9 columns or 8 columns or small number of columns.

Now, question, why a small number of columns will be good in this scenario? Right? Now, this one, that's a problem. I don't know. Ii will take us later during the break. Okay? Now, you do a there are some kind of, right, row flipping, and then column flipping, row flipping, column flipping is I write a number here, for example, row one, row three, column one, column four.

Ii can always encode your strategy into a sequence of rcrcrcci okay? Right? And then now my question is, if you should this operation in the sequence, will the final result change? For example, I flip row four first, and then column three. If I swap them, will the result be the same? I know. But so then what are you going to do? Remember, we are using this nine, right? What's your guess direction? Shifting does not affect the result, right? So then you have the strong intention to change the sequence in a certain way such that it looks very good. Which way looks very good? That is, I think we have these two either power to the times of you like you. But please, no, I I know your intention, but please answer my question directly.

What are you going to change the sequence? I means all the c in the front, very good. So that's the way, right. So you are changing. We are moving all the c to the beginning, see something. And then a lot of us. Why do you do that? Now imagine you do c first, right? After you finish all the c you try to flip roles that at that time will flip roles, be very easy.

In other words, we already decided how to flip columns, right? So after that, no more problems for me, no more column will be fit. And then I want you to decide which roles to fit. Well, that means, yes, man, why is it? Because I take a role, if according to what we I understood earlier, right? If this role is bad, now you need to fill it, and you don't need to revert the decision because column will no longer be flipped again, right? If row should be flipped now, then it should just be flipped. Nobody else will say this decision is wrong. Nobody will say that right? Okay. So your role flipping becomes very, very easy. You can just check every role individually and decide whether you should flip the role, right?

So now, you need all conflicting to be at the beginning, because otherwise, if some problem is there, they go over things, not straightforward, right? Now, this column, you only have 9 columns, right? 9 columns. Then you can do the famous operation. What operation? What's that word? They are integration, right? Now I can enumerate my column for me. I don't know how I live in my column, but actually enumerate. I can try every possibility, right? How many possibilities? Two to the nine. You have two to the 9th possible conflict. I tried everyone. And for each of them, I will play the role in an optimal way, right? Because as long as if confirm or decide how to flipping, roast, flipping is very easy, right? And then I I will draw a tree here. What's this tree? I will draw a tree. We didn't know tree yet, but I just try to show you something.

So basically, each such branch will mean one possible power flipping. For example, this that most branch could be 000000, or nine zeros. That means I do not have any problem. Zero zero needs to love it. Then the second branch could be 00000, something. One. Each branch corresponds to one possible conflict. Within each branch, you flip roles in the best way, right? That corresponds to the best solution in that branch. In this branch. What's the best solution? I found it.

说话人2 46:25  
Right?

说话人1 46:26  
Okay, because you decide the problem for me. And then with this background, you can flip roles very easily, right? Ok so in each branch, you can find the best the best solution. Here. I have the best solution. Here. I have the best solution here. I have the best solution here among all of these best solutions. I take the best one, the best of the best. That solution must be, the solution we are trying to look for, right?

So that's the issue is the whole thing. Any questions about practice? For, first of all, about practice? Any questions? This album is correct because I because the optimal solution must be in one of the branch, for example, you don't know which branch, but it must be one in one of them, for example, optimal solutions in this branch.

I've already made sure that in this branch, I find the best solution, then that resolution would just be the global optimal solution, because I said optimal is somewhere the middle in the branch.

Then in this branch, I found the best solution. Then this resolution is very good, right? It's just the optimal solution. Right? Correctness. It should be okay. If it's not okay, then you have 10 minutes in the break to discuss what appears. And now we're running time. What's the running time? You have two to the 9th conflicting strategy, right? For each of them, you decide whether you fix it or not, right? It just means they right, check all the points, and then number of points, what? 9:00 am right?

The total running time is 2 to the 9 × 9. And this running time is leading. It's even better than the wrong errors, right? Its organics about the 10,000 or 5,000 deposit. Yeah. ￥5,000 is about ￥5,000. Right? Any questions here? But this will be the most difficult information question I will add. Explain it. All right. Okay. Now the second question I will explain the question, and then you will have time to think about it during the break. Then we come back to the search ok second question is that? Second question? I also enjoy pick up here. Let me see what I should do. Maybe I just use this a it's a function. It's a function, 01234, and each has a value. For example, this value is here and two values here, three values here.

All right, is here that each Position you have a value for that position. This is f one is f two, f three, f four population from this scale. And it is now, what's the goal? The goal is to find the so called good test. Good pair of points. What is good pair? So good pair means, for example, these two are they form a good pair, because any point in between these 2 points, they are below this pair. Nothing about it, or everything is built. Everything is built is below the pair. Then we call it 2 pair. Next thing, we are trying to find a good pair whose slope is as large as possible. You have any good test. This is good pattern, and this one is also a good pattern. Right? This is also a good pair. So we are trying to find a good pair who sold the service. Right? So that is right. More steep, not the larger service, right? Okay. This is the goal.

Now we, first of all, need to find the solution one, which is the easiest solution. Can you tell me the easiest solution? And then during the break? And I think about that decision. Now, remember, I have a running time there. So easy solution, the running time should be big over n two, right? N times n higher n what's that matter? But if the starting . is not difficult, anyone raise your hand? We have two keywords. One is pet. That's good, right? Pet. Yeah, please. I think we can find the combination of two from the end. Okay? And for each of them, and after finding the peers, we can come here or we can analyze the situation in every very good.

So the point is II tried all the pairs, right? How many pairs do you have? Is n choose two, right? N elements choose two, so is roughly n squared n squared pairs. For each of them. You need to check whether this pair is good or not. Right? How to check the points between, right? You need to check whether that below the second, right, below the connection.

So how many points could be between this pair? In the worst case, we only have n points, n minus two points. All the other points are in between. They check every one of them. Basically only check n points to see whether they are below this pair altogether, the n squared times. And each parent check all the points, right? All the points in between to see whether this is a good pair. Finally, among all of the pairs, you take the largest one. That's another n squared. This is the first solution. Thank you. So now 10 minutes break. Please think about how to reduce it to n square or even n quality. You will sit down. We don't mention and we're all sitting in the sunshine. Now that is a little noise. Some of them in the hole, in the wall, some of the union. For that, I think that it is not the same. And that's the work of a lot of things for in the Chinese government.

This is a nice job today, the sunshine. That is the problem. Put it on sunshine. No. Yeah. Sure. So. Nana. On the busy come to attend. Is that in the yeah, and so forth. What it is. Are you calling? Ok talking about what colors are for the law and people. Company I column issue and he found this was an army diocese. It is. So you need to connection the board and please, so you need. So these guys are the customers finance economy. Means, look outside, I I think there are some markets is very capable. I don't want to say, I guess.