NUS National University of Singapore

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The Tourist Problem:
(Evolving the Problem Formulation)
Video 5.2a

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Experience the fun of problem solving

In Video 5.1, we start with 8 tourist

Given: A list of tourists, each with his/her list of places to visit.

To do: Schedule bus trips for them so that each tourist visits all the places in his list.

An Instance of Tourist Problem

Tourist	Places of Interest
Aaron	SZG, BG, JB
Betty	CG, JG, BG
Cathy	VC, SI, OR
David	JG, CG, OR
Evans	CG, JG, SZG
Frances	BG, SZG, JB
Gary	CG, OR
Harry	JG, CG

8 tourists,
8 places

We apply Simplification Rule…

Some Simplifications: Consider

- Aaron { SZG, BG, JB }
- ~~Frances { SZG, BG, JB }~~

Also consider

- David { JG, CG, OR }
- ~~Gary { CG, OR }~~

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Cathy	VC, SI, OR
David	JG, CG, OR
Evans	CG, JG, SZG
~~Frances~~	~~BG, SZG, JB~~
~~Gary~~	~~CG, OR~~
~~Harry~~	~~JG, CG~~

Simplification Rule:

If $P(T_1) \subseteq P(T_2)$, then tourist T_1 can just "follows" tourist T_2. Thus, we can omit T_1 from consideration.

Oh, can also omit Harry

- Betty { CG, JG, BG }
- ~~Harry { CG, JG }~~

Reduced TP Instance (5 tourists)

Given: A list of tourists, each with his/her list of places to visit.

To do: Schedule bus trips for them so that each tourist visits all the places in his list.

An Instance of Tourist Problem

Tourist	Places of Interest
Aaron	SZG, BG, JB
Betty	CG, JG, BG
Cathy	VC, SI, OR
David	JG, CG, OR
Evans	CG, JG, SZG

Every solution to this reduced instance…

… is a solution to the original problem instance!

$T = \{ A, B, C, D, E \}$

$P = \{ BG, CG, JB, JG, OR, SI, VC, SZG \}$

In this video…

We solve the Tourist Problem.

Then we iteratively reformulate the problem, give new solutions, analyze the solutions

We reach a good and interesting TP v1.0

The Tourist Problem – v0

Given: A list of tourist, each with his/her list of places to visit.

To do: Schedule bus rides for them so that each tourist visits all the places in his/her list.

Let's call this Tourist Problem Version 0 (TP v0)

In the software world, software & apps come in different versions, each version improving on previous ones in some ways.

An Instance of Tourist Problem

Tourist	Places of Interest
Aaron	SZG, BG, JB
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Cathy	VC, SI, OR
David	JG, CG, OR
Evans	CG, JG, SZG

Solving TP – Scheduling the bus trips

HW's universal rule on problem solving

"Given any problem, first give a *no-brainer solution*, if possible – even if it may not be the best solution."

(Here, HW is short for HonWai, but it is often confused with HomeWork.)

The Tourist Problem – v0

Given: **A list of tourist, each with his/her list of places to visit.**

To do: **Schedule bus rides for them so that each tourist visits all the places in his/her list.**

Q: Can you think up a No-Brainer solution?

An Instance of Tourist Problem

Tourist	Places of Interest
Aaron	SZG, BG, JB
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The Tourist Problem – v0

Given: A list of tourist, each with his/her list of places to visit.

To do: Schedule bus rides for them so that each tourist visits all the places in his/her list.

Q: Can you think up a No-Brainer solution?

Solution: (Singapore 1-Day Tour)

Put all the tourists on one bus.
Visit all eight places in 1 day.

An Instance of Tourist Problem

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David	JG, CG, OR
Evans	CG, JG, SZG

What's Good: It works! (One bus, one-day.)

What's Bad: Too rushed. (NO time to see anything!)

Not interesting!

Summary of situation (TP v0)

- Situation:
  - Happy Boss (likes 1 bus, 1 day, thinks $$$$)
  - Unhappy tourists (too rushed, no-time-2-C)
  - Situation is not stable in long run…
- You (intern) consults with unhappy tourist
  - Tourists lay down condition C1

  C1: every tourist visits at most 1 place per day

Effect of C1 on TP v0

"1 place per day" may be extreme

- But any fixed-length duration will work.
- So can also use "2 hours each, half-day each"
- We use "1 place per day" --- easier to say

Adding condition C1 to TP v0

- Changes the problem TP v0
- No-brainer solution don't work anymore!
- Need new solution, new formulation;

The Tourist Problem – v0.5

Given: A list of tourist, each with his/her list of places to visit.

To do: Schedule bus rides for them so that
each tourist visits all the places in his/her list, *and*

C1: Each tourist visits *at most one place a day*.

Simple Solution:

Schedule *one trip to every place every day*.

An Instance of Tourist Problem

Tourist	Places of Interest
Aaron	SZG, BG, JB
Betty	CG, JG, BG
Cathy	VC, SI, OR
David	JG, CG, OR
Evans	CG, JG, SZG

What's Good: It works! Finish in 3 days. (*minimum*!)

What's Bad: Wasteful! 24 bus trips.

Also, not so interesting!

Summary of situation (TP v0.5)

- Situation:
  - Happy tourists (free choice, done in 3 days)
  - Unhappy Boss (24 bus trips! thinks –$$$$)
  - unhappy boss is not healthy for intern…
- Boss summons poor intern
  - Boss lay down condition C2

  C2: at most 1 bus trip to each place

The Tourist Problem – v0.8

Given: A list of tourist, each with his/her list of places to visit.

To do: Schedule bus rides for them so that
each tourist visits all the places in his/her list,

C1: Each tourist visits *at most one place a day*, *and*

C2: There is *at most one bus trip to each place*

Simple Solution:

Schedule *one trip per day*,
each to a *different* place.

An Instance of Tourist Problem

Tourist	Places of Interest
Aaron	SZG, BG, JB
Betty	CG, JG, BG
Cathy	VC, SI, OR
David	JG, CG, OR
Evans	CG, JG, SZG

What's Good: It works! 8 trips.

What's Bad: It takes 8 days!

Summary of situation (TP v0.8)

Moral of the Story:

Be careful what you wish for, you may get it!

- Situation:
  - Tourists get what they want – C1 satisfied,
  - Boss gets what he wants – C2 satisfied,
  - Unhappy Boss (8 days, lost opportunity cost)
  - Unhappy tourists (8 days, time wasting)
- Both want to reduce number of days taken

The Tourist Problem – v1.0

Given: **A list of tourist, each with his/her list of places to visit.**

To do: **Schedule bus rides for them so that**
each tourist visits all the places in his/her list,
C1: Each tourist visits *at most one place a day*,
C2: There is *at most one bus trip to each place, and*
C3: *minimize* the number of days to complete mission.

Q1: How to reduce #days while still satisfying C1 and C2?

Q2: Can we modify from our solution for TP v0.8?

An Instance of Tourist Problem

Tourist	Places of Interest
Aaron	SZG, BG, JB
Betty	CG, JG, BG
Cathy	VC, SI, OR
David	JG, CG, OR
Evans	CG, JG, SZG

Let's see…

CONSTRAINTS:

C1: …tourist visits *at most one place a day*,

C2: …*at most one bus trip to each place, and*

C3: *minimize* the number of days

An Instance of Tourist Problem

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The notion of *conflict*

Eg: On the same day, cannot schedule BG and JB;
else Aaron will miss at least of them (he wants to visit both)

Definition: There is a ***conflict between two places X and Y*** if at least one tourist wants to visit both X and Y.

X and Y cannot be scheduled on the same day.

Let's see…

CONSTRAINTS:

C1: …tourist visits *at most one place a day*,

C2: …*at most one bus trip to each place, and*

C3: *minimize* the number of days

An Instance of Tourist Problem

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When can we schedule X and Y on the same day?

When there is ***no conflict*** between X and Y;

Meaning: *No* tourist wants to visit both X and Y)
(Must check with ***all the tourists***!)

Examples of No-conflict pairs:
(OR and SZG) and also (BG and CG)

How do we know? Must check with all the tourists!

Let's see…

CONSTRAINTS:

C1: …tourist visits *at most one place a day*,

C2: …*at most one bus trip to each place, and*

C3: *minimize* the number of days

An Instance of Tourist Problem

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Note that to schedule 3 places X, Y and Z on the same day, there must be no conflict
between (X and Y),
between (Y and Z), and
between (X and Z)

Can you find an example in our TP instance?

The Tourist Problem – v1.0

Given: A list of tourist, each with his/her list of places to visit.

To do: Schedule bus rides for them so that
each tourist visits all the places in his/her list,
C1: Each tourist visits *at most one place a day*,
C2: There is *at most one bus trip to each place, and*
C3: *minimize* the number of days to complete mission.

Check for non-conflicts to reduce the number of days.

There are many possible ways to combine bus trips together.

We want a bus schedule that minimizes the number of days

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TP Activity #1:

Bus Scheduling – the Direct Way

(10 minutes)

Instruction:

Download and print a copy of TP-Activity-1.pdf.

Then complete the activity – schedule the bus-trips so as to minimize the number of days taken to complete all the trips.

Have your answers ready at hand before continuing to Video **5.3.**

TP Activity 1: (10 minutes)

Tourist Bus Scheduling: The Direct Way

Tourist Problem Version 1.0
Given: A list of tourist, each with his/her list of places to visit.
To do: Schedule bus rides for them so that
each tourist visits all the places in his/her list, and
C1: Each tourist visits *at most one place a day,*
C2: There is *at most one bus trip to each place, and*
C3: *minimize* the number of days to complete mission.

An Instance of Tourist Problem

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Evans	CG, JG, SZG

Note the conflicts:
On same day:
* Cannot schedule BG and JB
(Aaron wants to visit both)
* Can schedule SZG and OR
(nobody want to visit both)

To schedule P1, P2, P3 on same day:
must check no conflict between
P1—P2, P2—P3, P1—P3;

Q1: Using the above information, try to schedule the bus trips.
Make sure to check *all* the conflicts.
(You want to minimize the # days needed to complete all the bus trips.)

Day 1: _____

Day 2: _____

(End of video 5.2)

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