#### Modeling Snow Removal for a Neighborhood

#### Using DEVS in CD++

#### Winter 2016

#### Assignment1

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**Conceptual Model**

The following is a simplified model to simulate snow removal throughout the winter season for a particular neighbourhood. The goal of this model will be to simulate conditions like regular and heavy snowfall and see how well the contractor handles the clearing of snow. Constraints such as time required to clear everything as well as total number of vehicles at one particular time deployed to the neighbourhood will be applied to maximize efficiently and minimize obstruction of vehicles for the residents.

The model will consist of 2 sub-models, the neighbourhood and the contractor hired to clear up the snow from that neighbourhood. The neighbourhood model will consist of 2 atomic models; one to model the walkways and one to model the roads as different machines and snow accumulation constraints are applied to each atomic model. Another main consideration will be when the walkways and roads can no longer store snow on the side and snow trucks will be required from the contractor to remove snow altogether from the neighbourhood. The high level simple input to output of the model is based on weather (input) and snow removed the neighbourhood by the contractor (output).Figure one below shows a brief sketch of the proposed model.

Snow Removal Model





Neighbourhood

w S\_A



w S\_A

Contractor

Snow\_Acc



Walkways

Snow

Weather

Vehicle

Roads

**Figure 1 Snow Removal Model**

The input to the neighbourhood is the weather forecast for next 4 hours (snow, rain, positive temp etc. ) which will affect the snow levels for the streets and roads. The neighbourhood will then output how much snow has been accumulated and once a threshold has been reached the contractor will be contacted to send vehicles to clear up snow. Depending on current levels as well as snowfall rate the number of vehicles active in the neighbourhood will change. Eventually throughout the season some snow will have to be removed through trucks based on how much has been accumulated on the sides if at all accumulated. The contractor will have a fixed number of vehicles for each task. There are two main tasks for the contractor, one is real time snow removal during or after snowfall, and second is removal of snow by trucks if snow accumulation gets too much.

**Assumptions for the model**

The model is a very abstract model .This a first implementation for this and certain assumptions have been taken to keep the scope of the assignment manageable.

* 2 types of vehicles type 1 clears snow directly on walkway or road and type 2 which clears side of walkway or road
* The type of vehicle sent will represent as an entity all the vehicles of that type in the neighborhood.
* For 2 cm of snow cleared from walkway 5 cm of snow is added to side (Arbitrarily chosen)
* For 3cm of snow cleared from road 7 cm of snow is added to the side (Arbitrarily chosen)
* Melting of snow by temperature is done as an input and the reason for that melt is not taken into account. As such passiveMelt is an input which will just subtract the value of the snowAccumulated on the side.
* Only one type of vehicle can be active on a type of surface. That is if vehicle type 1 is active on walkway then vehicle of type 2 cannot be active on walkway. (This behavior is taken care of in the contractor model and not the walkway or road model)

**Formal DEVS Specification of the Model**

As shown in figure 1 the snow removal model has an input of weather. For this model there can only be 2 types of weather inputs. Snowfall in centimeters and passive snow melting in centimeters (applied only to sides of the walkways and roads. The output is the periodic removal of snow from the neighborhood. The full model consists of 2 components: Neighborhood and contractor. The neighborhood outputs to the contractor based on weather input and vehicle activity, the amount of snow on the walkways and roads as well as the sides of the walkways and roads. The contractor then sends the appropriate type of vehicle depending on the type of surface (walkway or road) . The neighborhood has been divided into walkways and roads due to different types of vehicles required for each type as well as differing rates of snow accumulation on the side.

The DEVS specification along with pseudo code is stated below:-

<S, X, Y, δint, δext, λ, ta>

**Walkway:**

X={snow,passiveMelt,Vehicle1,Vehicle2} // Vehicle 1 is type of vehicle that clears off the walkway and //Vehicle 2 is type of vehicle that clears of the sides. snow is the input of snow in centimeters and passive //Melt is the snow in centimeters that was melted from sides. (passiveMelt is only applied to sides as //direct snow on the walkway will be cleared by Vehicle1)

Y={snowAccOn,snowAccSide} // snowAccOn is the snow accumulated on the walkway , snowAccSide is the snow accumulated on the side through snowfall as well as vehicle1 clearing.

S={phase , snowOn ,snowSide , onVehicle , sideVehicle}

// if there is snow on the neighborhood then become active

//snowOn is the snow on the walkway

//snowSide is the snow on the side

//onVehicle is true if there is a vehicle clearing walkway

//sideVehicle is true if there is a vehicle clearing the side (that is to remove via truck)

δext(snowOn,snowSide,onVehicle,sideVehicle , e, x)

{

case phase

passive:

if x is from snow

increment snowOn and snowSide value

phase is active (instantaneous)

if x from passiveMelt

decrement snowSide value

phase is active (instantaneous)

if x from vehicle1

set onVehicle true

decrement snow on walkway by 2cm

increment snow on side by 5 cm

time advance to time it takes for vehicle to do the clearing (4s)

phase is active

if x from vehicle 2

set sideVehicle true

decrement snow on side 5 cm

time advance to time it takes for vehicle to do the removing (10s)

phase is active

active

if x from vehicle 1 or vehicle 2

wait for one job to finish before starting(that is vehicle 2 will not start unless vehicle 1 is done)

}

δint(snowOn,snowSide,onVehicle,sideVehicle )

{

If state is active and there is no vehicle clearing walkway and there is a vehicle clearing side

If snow on side is greater than 5 centimetres keep clearing

Else set sideVehicle to false as no longer required

If state is active and there is a vehicle clearing walkway

If snow greater than 0 then keep clearing

Else

Send vehicle back and set onVehicle to zero

Else

Passivate and wait for input

Return this

}

λ(active)

{

Output snowAcc level for walkway and side.

}

Ta{clearing time for a vehicle , removal time for vehicle from side}

**Road:**

X={snow,passiveMelt,Vehicle1,Vehicle2} // Vehicle 1 is type of vehicle that clears off the road and //Vehicle 2 is type of vehicle that clears of the sides. snow is the input of snow in centimeters and passive //Melt is the snow in centimeters that was melted from sides. (passiveMelt is only applied to sides as //direct snow on the road will be cleared by Vehicle1)

Y={snowAccOn,snowAccSide} // snowAccOn is the snow accumulated on the road , snowAccSide is the snow accumulated on the side through snowfall as well as vehicle1 clearing.

S={phase , snowOn ,snowSide , onVehicle , sideVehicle}

// if there is snow on the neighborhood then become active

//snowOn is the snow on the road

//snowSide is the snow on the side

//onVehicle is true if there is a vehicle clearing road

//sideVehicle is true if there is a vehicle clearing the side (that is to remove via truck)

δext(snowOn,snowSide,onVehicle,sideVehicle , e, x)

{

case phase

passive:

if x is from snow

increment snowOn and snowSide value

phase is active (instantaneous)

if x from passiveMelt

decrement snowSide value

phase is active (instantaneous)

if x from vehicle1

set onVehicle true

decrement snow on road by 3 cm

increment snow on side 7 cm

time advance to time it takes for vehicle to do the clearing (6s)

phase is active

if x from vehicle 2

set sideVehicle true

decrement snow on side by 7cm

time advance to time it takes for vehicle to do the removing (13s)

phase is active

active

if x from vehicle 1 or vehicle 2

wait for one job to finish before starting(that is vehicle 2 will not start unless vehicle 1 is done)

}

δint(snowOn,snowSide,onVehicle,sideVehicle )

{

If state is active and there is no vehicle clearing road and there is a vehicle clearing side

If snow on side is greater than 7 centimetres keep clearing

Else set sideVehicle to false as no longer required

If state is active and there is a vehicle clearing road

If snow greater than 0 then keep clearing

Else

Send vehicle back and set onVehicle to zero

Else

Passivate and wait for input

Return this

}

λ(active)

{

Output snowAcc level for road and side.

}

Ta{clearing time for a vehicle , removal time for vehicle from side}

**Contractor:**

X={snowAccOnW,snowAccOnSideW, snowAccOnSideR, snowAccOnR }

// snowAccOnW is snow accumulated on walkway

//snowAccOnSideW is snow accumulated on side of walkway

//snowAccOnSideR is snow accumulated on side of road

//snowAccOnR is snow accumulated on Road

Y={vehicle1W, vehicle2W , vehicle1R , vehicle2R ,snowRemoved}

//vehicle1W, vehicle of type 1 for walkways sent

//vehicle2W , vehicle of type 2 for walkways sent

//vehicle1R , vehicle of type 1 for road sent

//vehicle2R ,vehicle of type 2 for road sent

//snowRemoved total snow removed when vehicle will come back internally stored separately for walkways and roads but as output distinction is not made.

S={phase , v1walkway ,v2walkway ,v1road , v2road}

Phase is passive just waiting for input and indication to send vehicles.

If a particular type of vehicle is sent then the state is active and will remain active until that type of vehicle returns.

δext(v1walkway ,v2walkway ,v1road , v2road, e, x)

{

// walkway case

if message is snow on walkway and vehicle of type 2 not active

if snow more than 3cm and a vehicle is not already active

set state active after 1 sec (travel time for vehicle)

vehicle 1 active

else if snow is 0 and vehicle of type1 is active

it has done the job and should come back

set passive after 1 sec (travel time)

vehicle 1 inactive

else do nothing as vehicle of type 1 is active already and can’t do more

passivate

if message is snow on sideway and vehicle of type 1 is not active

if snow higher than 25cm and vehicle of type not already active

set state active after 1 sec (travel time for vehicle)

store snow that will be removed

vehicle 2 active

else if snow less than 5 cm and type 2 vehicle active

done job , come back

set passive after 1 sec

vehicle 2 in active

else do nothing as vehicle of type 2 is active already and can’t do more

passivate

// road case

if message is snow on road and vehicle of type 2 not active

if snow more than 3cm and a vehicle is not already active

set state active after 1 sec (travel time for vehicle)

vehicle 1 active

else if snow is 0 and vehicle of type1 is active

it has done the job and should come back

set passive after 1 sec (travel time)

vehicle 1 inactive

else do nothing as vehicle of type 1 is active already and can’t do more

passivate

if message is snow on sideway and vehicle of type 1 is not active

if snow higher than 25cm and vehicle of type not already active

set state active after 1 sec (travel time for vehicle)

store snow that will be removed

vehicle 2 active

else if snow less than 5 cm and type 2 vehicle active

done job , come back

set passive after 1 sec

vehicle 2 in active

else do nothing as vehicle of type 2 is active already and can’t do more

passivate

δint(); this case internal transition function just waits for input

λ(v1walkway ,v2walkway ,v1road , v2road)

{

If vehicle1 on walkway and active and the input came from snow on walkway

Send vehicle 1

If vehicle2 on walkway and active and the input came from snow on side walkway

Send vehicle 2

If !vehicle2 on walkway and passive and the input came from snow on side walkway

Output snow as this means vehicl2 has returned

If vehicle1 on road and active and the input came from snow on road

Send vehicle 1

If vehicle2 on road and active and the input came from snow on side of road

Send vehicle 2

If !vehicle2 on walkway and passive and the input came from snow on side of

Output snow removed as this means vehicle2 has returned

}

Ta{travelling time for vehicles}

**Coupled Models**

<X, Y, D, {Mi}, {Ii}, {Zij}, SELECT >

**Neighbourhood:**

Neighbourhood consists of a walkway and road model. Each takes 4 types of inputs

X={snowW ,snowR ,Vehicle1W, vehicle1R,vehicle2W,vehicle2R,passiveMeltW,passiveMeltR }

Y={ snowAccOnW,snowAccOnSideW, snowAccOnSideR, snowAccOnR }

D = {walkway,road}

EIC(walkway) = {(self,snowW),(walkway,snowW);( self,vehicle1W),(walkway, vehicle1W ); (self,vehicle2W),(walkway,vehicle2W);(self,passiveMeltW),(walkway,passiveMeltW) }

EIC(road) = {(self,snowR),(road,snowR);( self,vehicle1R),(road, vehicle1R ); (self,vehicle2R),(road,vehicle2R);(self,passiveMeltR),(walkway,passiveMeltR) }

EOC(walkway) ={(walkway,snowAccOnW),(self,snowAccOnW);(walkway,snowAccOnSideW),(self,snowAccOnSideW)}

EOC(road) ={(road,snowAccOnW),(self,snowAccOnR);(road,snowAccOnSideW),(self,snowAccOnSideR)}

IC = {} //no internal coupling for neighbourhood

Select{} irrelevant as walkway and road are not really coupled in the true sense of the word

**SnowRemovalModel**

**Consists of neighbourhood and contractor .**

X={snowW ,snowR , passiveMeltW,passiveMeltR }

Y={ snowRemoved }

D = {neighbourhood,contractor}

EIC = {(self,snowW),(neighbourhood,snowW);(self,passiveMeltW),(neighbourhood,passiveMeltW) }

EOC= {(contractor,snowRemoved),(self,snowRemoved)}

IC (neighbourhood to contractor)= {(neighbourhood,snowAccOnW),(contractor,snowAccOnW);(neighbourhood,snowAccOnR),(contractor,snoAccOnR); (neighbourhood,snowAccOnSideW),(contractor,snowAccOnSideW);(neighbourhood,snowAccOnSideR),(contractor,snowAccOnSideR)}

IC(contractor to neighbourhood) = {(contractor,),( vehicle1W),(neighbourhood,vehicle1W);(contractor, vehicle2W),(neighbourhood,vehicle2W);(contractor,),(vehicle1R),(neighbourhood,vehicle1R);(contractor, vehicle2R),( neighbourhood,vehicle2R)}

Select{neighbourhood,contractor}

**Testing cases and analysis**

**Atomic Model for walkway**

The walkway was tested by giving inputs of snow and then sending in vehicles of type 1 and 2 to see how snow levels were effected. The input of passivemelt was checked as well the results are explained below.

Events:-

00:00:00:00 snow 1

00:00:05:00 snow 10

00:00:06:00 vehicle1 1

00:04:40:00 vehicle2 1

00:06:05:00 snow 5

00:06:06:00 vehicle1 1

00:06:20:00 passivemelt 3

As the first event is sent in at time 0 the snow level on the side as well as on the walkway is increased by 1cm. The second input of 10 increases both snow on side as well as snow on the walkway to 11cm.

Vehicle type 1 is sent to clear snow from the walkway at time 6s. Subsequently after every 4 seconds there is an ouput to indicate how much snow has been cleared from walkway and how much snow has been added to side of walkway.By 00:00:30:000 the snow has been cleared from the walkway completely and vehicle 1 stops . Snow is at 40 cm for the side. Then vehicle of type 2 is sent to remove snow from the walkway . Every 10 seconds there is output to indicate the removal and by 00:05:50:000 the side is cleared to 5 cm so the vehicle stops as that was the condition for it to stop.

There has been additional testing done by adding another 5 cm of snow which increases both the snow on walkway and the side to 5cm and 10cm respectively (00:06:05:000). The passive melt input is checked at 00:06:20:00 which will decrease the snow on side by 3 cm which it does in the output file

Ouput:-

00:00:00:000 snowaccon 1

00:00:00:000 snowaccside 1

00:00:05:000 snowaccon 11

00:00:05:000 snowaccside 11

00:00:10:000 snowaccon 9

00:00:10:000 snowaccside 16

00:00:14:000 snowaccon 7

00:00:14:000 snowaccside 21

00:00:18:000 snowaccon 5

00:00:18:000 snowaccside 26

00:00:22:000 snowaccon 3

00:00:22:000 snowaccside 31

00:00:26:000 snowaccon 1

00:00:26:000 snowaccside 36

00:00:30:000 snowaccon 0

00:00:30:000 snowaccside 40

00:04:50:000 snowaccon 0

00:04:50:000 snowaccside 35

00:05:00:000 snowaccon 0

00:05:00:000 snowaccside 30

00:05:10:000 snowaccon 0

00:05:10:000 snowaccside 25

00:05:20:000 snowaccon 0

00:05:20:000 snowaccside 20

00:05:30:000 snowaccon 0

00:05:30:000 snowaccside 15

00:05:40:000 snowaccon 0

00:05:40:000 snowaccside 10

00:05:50:000 snowaccon 0

00:05:50:000 snowaccside 5

00:06:05:000 snowaccon 5

00:06:05:000 snowaccside 10

00:06:10:000 snowaccon 3

00:06:10:000 snowaccside 15

00:06:14:000 snowaccon 1

00:06:14:000 snowaccside 20

00:06:18:000 snowaccon 0

00:06:18:000 snowaccside 24

00:06:20:000 snowaccon 0

00:06:20:000 snowaccside 21

**Atomic Model for Road**

The road atomic model was tested in similar scenario the event file is below

Event:-

00:00:00:00 snow 1

00:00:05:00 snow 10

00:00:06:00 vehicle1 1

00:04:40:00 vehicle2 1

00:06:05:00 snow 5

00:06:06:00 vehicle1 1

00:06:20:00 passivemelt 3

Similarly the snow level rises with snow input upto 11cm on the side as well as on the road as shown in the ouput file at time = 00:00:05:000 . At time 6s vehicle 1 is sent to clear snow on the road and subsequently progress is output every 6 seconds. Snow on the road gradually decreaseas and snow on the side increases until 00:00:30:000 when all the snow from the road has been removed. Snow on the side of the road is at 34 cm at this point. Then vehicle of type 2 is sent and subsequently every 13 seconds the snow from the side is removed by 7cm up until it gets below or equal to 7cm which is at time 00:05:32:000 . The passivemelt input was also checked which decreased the snow on the side of the road from 20cm to 17 cm.

Output-:

00:00:00:000 snowaccon 1

00:00:00:000 snowaccside 1

00:00:05:000 snowaccon 11

00:00:05:000 snowaccside 11

00:00:12:000 snowaccon 8

00:00:12:000 snowaccside 18

00:00:18:000 snowaccon 5

00:00:18:000 snowaccside 25

00:00:24:000 snowaccon 2

00:00:24:000 snowaccside 32

00:00:30:000 snowaccon 0

00:00:30:000 snowaccside 34

00:04:53:000 snowaccon 0

00:04:53:000 snowaccside 27

00:05:06:000 snowaccon 0

00:05:06:000 snowaccside 20

00:05:19:000 snowaccon 0

00:05:19:000 snowaccside 13

00:05:32:000 snowaccon 0

00:05:32:000 snowaccside 6

00:06:05:000 snowaccon 5

00:06:05:000 snowaccside 11

00:06:12:000 snowaccon 2

00:06:12:000 snowaccside 18

00:06:18:000 snowaccon 0

00:06:18:000 snowaccside 20

00:06:20:000 snowaccon 0

00:06:20:000 snowaccside 17

**Coupled Model for Neighborhood**

The coupled model for neighborhood was tested using similar concept as before . The event file is below.

Event:-

00:00:00:00 snoww 1

00:00:05:00 snoww 2

00:00:05:00 snowr 10

00:02:55:00 snoww 1

00:02:55:00 snoww 6

00:02:57:00 passiveMeltw 2

00:04:00:00 vehicle1r 1

00:04:00:00 vehicle1w 1

The first 2 inputs are of snow for walkway and thus the outputs are also of snow accumulated on walkway . This bring snow level for walkway to 3 cm. The third input was for snow on road and thus the output was for snow on road as indicated at 00:00:05:000 in the ouput file. The passivemelt input for the walkway also decreases just the walkway and not the road snow .The interesting result is when both type 1 vehicles are active on a walkway and a road. Vehicle1 on the road every 6 seconds ouputs the snow levels accordingly , vehicle1 on walkway outputs the snow levels accordingly every seconds as can be seen in the ouput file starting from 00:04:04:000 .

Output:-

00:00:00:000 snowacconw 1

00:00:00:000 snowaccsidew 1

00:00:05:000 snowacconw 3

00:00:05:000 snowaccsidew 3

00:00:05:000 snowacconr 10

00:00:05:000 snowaccsider 10

00:02:55:000 snowacconw 10

00:02:55:000 snowaccsidew 10

00:02:57:000 snowacconw 10

00:02:57:000 snowaccsidew 8

00:04:04:000 snowacconw 8

00:04:04:000 snowaccsidew 13

00:04:06:000 snowacconr 7

00:04:06:000 snowaccsider 17

00:04:08:000 snowacconw 6

00:04:08:000 snowaccsidew 18

00:04:12:000 snowacconw 4

00:04:12:000 snowaccsidew 23

00:04:12:000 snowacconr 4

00:04:12:000 snowaccsider 24

00:04:16:000 snowacconw 2

00:04:16:000 snowaccsidew 28

00:04:18:000 snowacconr 1

00:04:18:000 snowaccsider 31

00:04:20:000 snowacconw 0

00:04:20:000 snowaccsidew 33

00:04:24:000 snowacconr 0

00:04:24:000 snowaccsider 31

**Atomic Model for Contractor**

The atomic model for contractor was tested using the ouputs from the road model to see if it is working as intended. For simplicity and easier identification road and walkway were tested separately but both produced intended results. Only road is included in the results.

Event file for contractor (output from road testing)

00:00:00:000 snowacconr 1

00:00:00:000 snowaccsider 1

00:00:05:000 snowacconr 11

00:00:05:000 snowaccsider 11

00:00:12:000 snowacconr 8

00:00:12:000 snowaccsider 18

00:00:18:000 snowacconr 5

00:00:18:000 snowaccsider 25

00:00:24:000 snowacconr 2

00:00:24:000 snowaccsider 32

00:00:30:000 snowacconr 0

00:00:30:000 snowaccsider 34

00:04:53:000 snowacconr 0

00:04:53:000 snowaccsider 27

00:05:06:000 snowacconr 0

00:05:06:000 snowaccsider 20

00:05:19:000 snowacconr 0

00:05:19:000 snowaccsider 13

00:05:32:000 snowacconr 0

00:05:32:000 snowaccsider 6

00:06:05:000 snowacconr 5

00:06:05:000 snowaccsider 11

00:06:12:000 snowacconr 2

00:06:12:000 snowaccsider 18

00:06:18:000 snowacconr 0

00:06:18:000 snowaccsider 20

00:06:20:000 snowacconr 0

00:06:20:000 snowaccsider 17

00:06:25:000 snowacconr 10

00:06:25:000 snowaccsider 27

00:06:36:000 snowacconr 7

00:06:36:000 snowaccsider 34

00:06:42:000 snowacconr 4

00:06:42:000 snowaccsider 41

00:06:48:000 snowacconr 1

00:06:48:000 snowaccsider 48

00:06:54:000 snowacconr 0

00:06:54:000 snowaccsider 48

00:07:13:000 snowacconr 0

00:07:13:000 snowaccsider 41

00:07:26:000 snowacconr 0

00:07:26:000 snowaccsider 34

00:07:39:000 snowacconr 0

00:07:39:000 snowaccsider 27

00:07:52:000 snowacconr 0

00:07:52:000 snowaccsider 20

00:08:05:000 snowacconr 0

00:08:05:000 snowaccsider 13

00:08:18:000 snowacconr 0

00:08:18:000 snowaccsider 6

At 5 seconds in the snow on the road is at 11 cm as well as on the side , but precedence in the logic of the model is given to first clearing the direct snow as is intuitive. 1 second later the contractor outputs vehicle of type 1 to clear snow. Note the input is decreasing independent of the vehicle being there or not. All the contractor knows is that vehicle type 1 is active currently. By 30 seconds the snow on the road is clear but the snow on the side is at above 25 cm so vehicle 2 is sent at 31 seconds. The contractor doesn’t care how long it will take to remove all that snow and just waits for it to get below threshold. At 00:05:32:000 the snow is at 6 cm to vehicle type 2 comes back and 1 second later snow removed is output. There was 34 cm when vehicle was sent , and now 6 left , so total removed is 28cm. More tests were done but not required and the output matched again that is the 42cm made sense.

Output from contractor:

00:00:06:000 vehicle1r 1

00:00:31:000 vehicle2r 1

00:05:33:000 snowremoved 28

00:06:06:000 vehicle1r 1

00:06:26:000 vehicle1r 1

00:06:55:000 vehicle2r 1

00:08:19:000 snowremoved 42

**Coupled Model for SnowRemovalModel**

The final coupled model was made by combining the neighborhood and contractor model. The results and tests were to specifically verify the number of the snowRemoved. Snow Removed from road as well as snow removed from walkway. The event file is as follows :-

00:00:00:00 snoww 1

00:00:05:00 snoww 2

00:00:05:00 snowr 10

00:02:55:00 snoww 1

00:02:55:00 snoww 6

So snow falls on the walkway which inreases it to 1 cm, then 2cm more brings it upto 3 cm. This triggers vehicle 1 to only bring it down to 0 cm and snow on side is raised to 9cm. This is for walkway. For the road 10 cm of snow is sent as input which causes vehicle 1 to be active for the roads and bring snow up to around 34cm on the sides.(`around word used as formula for clearing is not linear that is to say 1cm of clearing on road does not add 1cm to side but more) This triggers vehicle 2 to start clearing the sides and it removes till 6cm is left bring the total snow removed to 28cm. This is what is output in the output file.

There is a total of 7cm snow when vehicle 1 triggers again for walkway. The snow on the side was already 9 cm which brings it up to 16cm. By the time vehicle 1 is done clearing the walkway again the snow on the side is upto around 35 cm. Vehicle 2 for walkway gets triggered and removes till there is only 5 cm left which means total snow removed 2nd time is 30 cm as shown by the ouput.

Ouput file

00:01:24:000 snowremoved 28

00:04:15:000 snowremoved 30