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NEXT GENERATION OF VIRTUAL STOPS FOR FUTURE MOBILITY SOLUTIONS

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Agenda



- Introduction
 - Virtual stops
 - Example of virtuals stops
 - Virtual stops and related mobility solutions
- Criteria for the placement & selection of virtual stops
 - Technical & nontechnical requirements
- Oveview of the mobility solutions related to the virtual stop
- Conclusion and outlook

Introduction (1) Virtual stops

Virtual stops (1) are fixed locations on the road where <u>mobility service</u> (2) <u>passengers</u> (3) can use on-demand <u>vehicles</u> (4) (e.g. a shuttle bus).

Our research contribution:

- Research and investigation of the requirements for these stops from the perspective of the vehicles and the users.
- Research and development of some prototype mobility solutions in the context of virtual stops



Introduction (2) Example of virtual stops



Categories of virtual stops (VS)



- In principle, any safe and feasible location in the road network can be defined as a "virtual" or "unconventional" stop
- The possible location for a virtual stop can also be mapped to the "physical" existing stop, for example, a "conventional" bus stop
- The virtual stop can also be viewed as a special form of parking space.



Criteria for the placement or selection of virtual stops



Criteria for placement on the road

Research questions

- Which general criteria does a stop have to meet in order to act as a virtual stop on the road?
- Which specific criteria should a stop meet in order to fulfil the needs of different user groups and stakeholders?

Criteria for selection for mobile solutions

Research questions

- What criteria must a virtual stop fulfil in order to meet the specific requirements of different users or vehicles?
- Which virtual stops can be used at the service time?
- What criteria make the virtual stops comparable so that the optimal one can be selected?

Criteria categories:



Criteria for the placement or selection of virtual stops (1)



No	Criteria	Part	ies con	iceme	d	Specification	Measurement	Description	Relevant for	
		User	Vehicle	Provider	Municipal- ity				Placement	Choose
1.a		Ø				Disabled access [12]	Is available (yes or no)	 Can be very specific depending on the nature of the disability (e.g. walking impediment, visual impairment) 	Ø	Ø
1.b	Barrier-	Ø				Space for loading/unload- ing luggage or strollers	Is available (yes or no)		Ø	Ø
1.c	free	Ø				Direct access from/to the footway available	Is available (yes or no)	 There is no bike lane or grass verge 	Ø	Q
1.d			Q			Space to fold out the ramp of the vehicle	Is available (yes or no)	 Depends on the available ramp of the vehicle (lateral or at the back) 	Ø	Ø
2.a		Ø				Electrical lighting is avail- able	Is available? (yes or no)	When getting in and out of the vehicle	Ø	Ø
2.b		Ø				Surveillance camera are available	Is available? (yes or no)		Ø	Ø
2.e	C - C + + +	Q				Low traffic area	Is the virtual stop located at the low traffic area? (yes or no)	 E.g. Low traffic area consists of road with speed limit 30 km/h 	Ŋ	Q
2.f	Safety	Ø				Pedestrian crossing is available	Is a pedestrian road crossing availa- ble? (yes or no)	 E.g. pedestrian road crossing 	Q	Q
2.g		Ø	Ŋ			Compact road surface	Surface of the road allows a stable stop	Can be affected by: • Potholes • Inclination • Slippery ground	Ø	

Criteria for the placement or selection of virtual stops (2)



No	Criteria	Partie	es con	ncerned Specification		Specification	Measurement	Description	Relevant for		
		User	Vehicle	Provider	Municipal- ity				Placement	Choose	
								 Material of the surface 			
2.h					Ø	Increased risk of accidents with the vehicle [14]	Is the typical traffic flow disturbed? (yes or no)	 E.g., caused by stop At crossings In the second row (next to parking vehicles) 	Ø	Ø	
3.a		Ø				(Maximal) Distance (Length) of the footway / dis- tance from the user actual po- sition to the pickup virtual stop	Distance [in meter]	 Maximal Distance that the user has to travel from his actual position to location of the vir- tual stop Measurement by pedestrian routing Depending on the season, mobility and bag- gage or total travel time 		Ø	
3.b		Ø				(Maximal) travel time to the virtual stop	Time [in minute]	 The time that the passenger needs to reach the virtual stops 		Ø	
3.c	Accessi- bility	Ø				Complexity of the pedes- trian route to the virtual stop (small detour)	Number of intersections / turns, curve, road category	 The necessary steps to find the way to the given stop. E.g., how often does the user have to turn, are there main roads or intersec- tions that the user has to cross 		Ø	
3.d		Ø				Maximal duration of wait- ing time at the virtual bus stop until pickup	Time [in minute]	 The time that the passenger has to wait for the shuttle to arrive after arriving at the vir- tual stop Define the maximum time a passenger should wait at the virtual stop until the vehi- cle arrives 		Ø	
3.e		Ø				Accessibility of virtual stop using public transport is possi- ble	Number of train stations, tram sta- tions, bus stops, and taxi stations at the virtual stop area	 Set the maximum value Connection to the bus rail, tram, taxi transport services 	Ø	Ø	
3.f		Q				Pedestrian road crossing is possible	Is available at the virtual stop area? (yes or no)	•	Ø	Ø	

Criteria for the placement or selection of virtual stops (3)



No	Criteria	Part	ies cor	icerne	ed	Specification	Measurement	Description	Relevan	t for
		User	Vehicle	Provider	Municipal- ity				Placement	Choose
3.g			Ø			Vehicle has enough space to stop at the virtual stop	Vehicle fits into the virtual stop? (yes or no)	Depends on the lengths of the used vehicles	Ø	Ø
3.h			Ø			Vehicle has the right to reach the virtual stop	There are (currently) no restrictions such as taxi stand or one-way street which does not impede the driving on of the virtual stop (yes or no)	 Provider dependent contracts can affect these restrictions Can depend on the characteristics of the vehicle as the weight 	Ø	Ø
3.i			Ø			Vehicle has the right to stop at the virtual stop	There are (currently) no restrictions specified by traffic regulations (yes or no)	see Table 1	Ø	Ø
3.j			Ø			Near to main roads	Time to access the superordinate road network [in minutes]	 Relevant for long trips especially in rural ar- eas to reduce the detour 	Ø	Ø
3.k			Ø			Avoid typical areas of con- gestions	Time depending on the current traf- fic situation the vehicle can reach and/or leave the virtual stop [in minutes]	 Traffic situation can also be derived from historical data 		Ø
3.1			Ø			Virtual stop is empty	The virtual stop can be used at the time of the request or an alternative stop is available (yes or no)	 The virtual stop can be shared with public transport Virtual stop should be booked/blocked, if possible 		Ø
4.a		Ø				Shelter facilities are availa- ble	Is available at the virtual stop area? (ves or no)			Ø
4.b		Ø				Seats facilities are availa- ble	Is available at the virtual stop area? (ves or no)			Ø
4.c	Conven- ience /	Q				Toilet is available	Is available at the virtual stop area? (yes or no)			Ø
4.đ	comfort	Ø				Paid or free parking is available for own vehicles	Is available at the virtual stop area? (yes or no)	Prefer low parking fees or free of charge		Ø
4.e		Ø				Low traffic area	Is available at the virtual stop area? (yes or no)		Ø	

Criteria for the placement or selection of virtual stops (4)



No	Criteria	Part	ies con	icerne	d	Specification	Measurement	Description	Releva	nt for
		User	Vehicle	Provider	Municipal- ity				Placement	Choose
4.f				Q		High acceptance of the user	Are all criteria relevant for the user fulfilled? (ves or no/ how many?)			Ø
5.1	Unique- ness /	Ø				At intersection	Is near an intersection? (yes or no)	 The precise point of stop must be clear 	Ø	
5.b	findabil- ity	Ø	Ø			POIs for identification of virtual stop available	Is near a POI? (yes or no)	The street site must be clear	Ø	
0.a	Costs			Ø		Parking fees	Cost if the virtual stop is used [in EUR or similar]	 Contracts with the supplier of the parking place can reduce the costs 		
6.b				Ø		Near charging infrastruc- ture	Is charging currently needed? (yes or no)	 Reduce costs to combine charging with the stop or at least shorten the way to the charg- ing infrastructure 	Ø	Ø
6.c				Ø		Short entire route	Is there another virtual stop that can be used near the current route? (yes or no)	 Use virtual stops near the current route Prefer virtual stops of the current route ("common meeting points") 		Ø
7.a	Privacy / data pro- tection	Ø				Address not traceable	Is available at the virtual stop area? (yes or no)	Stop at POI or minimum distance to address		Ø
8.a	Cover- age			Ø		Density of the virtual stops within the service area	Is there at least one virtual stop near all potential requests? (yes or no)	 Important especially for public providers Three different strategies of commercial providers are described in [Harmann et al. [2]] 	Ø	
9.a	Impact on the traffic flow				Ø	No negative impact on the traffic flow	Does a stop at the virtual stop causes a congestion? (yes or no)	Is influenced by: The current traffic <u>flow</u> Sufficient wide road Main or side road Stop on the lane or parking bay		

Mobility solutions in context of virtual stops Demand Responsive Transport (DRT)



Use case scenario: DRT using virtual stop (VS)

- End user books the trip von A to B using the Keep Moving mobile App
- The disposition system (DS) as backend or cloud service provides the route, the start, destination VS and the corresponding scheduled shuttle and time
- The user walks to the pickup point (start VS)
- The connected automated (CA) shuttle drives from the depot to the start VS (A) picks up the user, drives to the destination VS (B), drops up the user and drives back to the depot.





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3. Disposition

System

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7. Traffic

Infrastructure

5. Traffic

Management

System

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Mobility solutions in context of virtual stops Implementation

- Mobility solutions / Use case scenarios (1)



Mobility solutions in context of virtual stops Implementation



The user books the on-demand mobiliy trip using VS from A to B via KeepMoving app The user recognition of VS and CA Shuttle using AR mobile app at pickup location Assigment of VS to the single CA Shuttle and management \rightarrow TMC









Mobility solutions in context of virtual stops Implementation



KeepMoving App

KeepMoving On-Demand Dashboard



Conclusion and Outlook



- The concepts for new virtual stops as an integral part of the roadside infrastructure for future mobility solutions are presented in this contribution
- The paper gives the answer to these questions: which criteria does a public transport bus stop, on-street parking or parking bay have to meet so that it can act as a virtual stop or chosen by the end user like on-demand passenger of demand responsive transport?
- This paper illustrates also the most significant mobility uses cases where virtual stops are involved, such as demand responsive transport (DRT), automatic identification and occupancy status detection, automatic recognition using augmented reality for on-demand service users and management through effective assignment to the on-demand autonomous vehicle
- In the next step, the criteria for the placement and selection of virtual stops presented in this contribution will be evaluated in detail and the results according to the end user and vehicle expectation will be part of the next publication
- The contribution presented in this paper describes the activities of the German mobility research project KoKoVi, founded by the German Federal Ministry for Digital and Transport

Thank you for your attention

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