

Project 3

For project three I want you to conceive, design, implement and build a sufficient, peer-to-peer networking protocol, with a mandatory use case scenario alongside Low Earth Orbit Satellites e.g. Starlink or OneWeb Constellations.

By way of context, as of today, there are 7073 Starlink satellites reported in LEO, providing service to > 4M customers in >100 countries (Source: SpaceX x.com 26/9/24)

You can find out more about some of the communication and networking characteristics of Starlink satellites here: <https://arxiv.org/pdf/2306.07469> and here: <https://blog.apnic.net/2024/05/17/a-transport-protocols-view-of-starlink/>

Your emulated use case for demonstration and testing purposes can be any sufficiently realistic, scalable use case of your choosing e.g. vehicular mobility contexts, remote exploration, underwater search and rescue missions, etc.

You must demonstrate how and where your implementation/system is specifically designed to interoperate with, and potentially enhance, the performance characteristics of your use case in such a LEO space communication setting.

An example of such a technical concept may be an implementation that helps mitigate the ISL or handover delay that characterizes (inter-) satellite communications. Closer to the application and end-user, one could consider how hybrid wired and satellite capabilities can be best overlaid to achieve certain functional goals.

For your chosen scenario(s), you must create multiple representations of sufficiently realistic LEO communication 'channels' (multiple) for communication to happen over. You should also create emulations of any channel or interconnects where such channels may form part of your solution's end-to-end communication pathway. Please implement no less than 5 separate and distinct "satellite" device instances on each 'network' path, with each device instance being able to accept no less than 5 simultaneous parallel connections from earth based data sources. Your solution must be able to demonstrate that each data source is demonstrably sufficiently realistically interacted with, and with data effectively transferred between end nodes. Each end-end communication pathway(s) should be demonstrated to credibly emulate scalable entities, network functionalities and communication characteristics appropriate to the chosen setting/use case.

A key intent of this project is to cause you to clearly focus on present day real world communication and interaction with scalable systems, and to propose concepts that can be utilized in challenging contexts.

This is a **WHOLE group FULLY ACTIVE participation** project. If either a majority of your group, or the lecturer, view you as having failed to fully contribute your score for Project 3 will be reduced. Groups are included below.

Deadlines are as per blackboard and the online demo interview calendar.

Requirements, Constraints and Suggestions:

- i) You may not assume communication with infrastructure gateway nodes or infrastructure participants, *-except-* where your system securely engages with such a node as an integral part of your communication solution as part of its regular operations. In such a

Project 3

case, LEO process and communications, and their purpose, should be clearly evident throughout. The clear separation, and handling, of any control and data messaging in an LEO signalling/communication context should be evident.

- ii) You must implement and demonstrate your system on your groups RPi(s), to the greatest extent practicable. Practical demonstration will form part of the live interview before the end of semester. Where you implement functionalities off-Pi, you should provide a clear, cogent and convincing articulation for said decisions – and the realism of same.
- iii) You should implement no less than the prescribed number and types of devices and entities per device. You are free to implement as many more as you see fit.
- iv) Your approach and solution should be both carefully considered and highly in design and implementation. It must be sufficiently robust to the failure of one or more nodes and/or channels and/or networks. You will be required to demonstrate these capabilities, and the associated signaling and communication modalities. These will be key assessment aspects of your solution.
- v) Your specific, assessable implementation should provide for, and clearly demonstrate, ISL and alternative channel concepts appropriate to your chosen use case. You may use any appropriate LEO and/or parallel channel mobility, discovery, routing and/or other approach/model(s) as your group agree appropriate to the task. These design and implementation decisions should be both local and specific to your group. Please document your choices and rationales as part of the final design document that will be required as a submission from each group.
- vi) I suggest that not only each group, but many groups, discuss and agree collaborative approaches to this task – particularly for effective and scalable LEO and ISL constructs. Device models and concepts for models can be openly discussed and shared on Piazza, subject to each group fully understanding all code and models they choose to use or rely on. You know I will also quiz you on this in interview.

Bonus:

1. Bonus marks will be available for demonstrating clear, convincing and scalable *secure* LEO channel interoperability (during live interview) with independent implementations by other groups. (5)
2. Bonus marks will be available for implementing and demonstrating enhanced system capabilities through the appropriate and targeted use of AI/ML techniques to/for aspects of the security or improved performance characteristics that you incorporate in your solution. (10)

Assessment:

Assessment will be via three submissions and one live group interview. If you fail to contribute to any of these elements, your score will be reduced/zero on that element.

Project 3

- i) Project 3 final group report (group report – highlighting how you satisfied all requirements; what you did, how you did it, why you did it that way, why it matters; – submit via Blackboard)
- ii) Project 3 final codebase (please highlight using comments the main areas of contribution of each group member to the uploaded codebase) – submit via BlackBoard
- iii) Peer and group evaluation and self-assessment --- link to follow
- iv) Live group interview and demo 16-17 Nov – book your GROUP slot here (only 1 booking per group): booking link will be updated in the main project 3 blackboard post shortly.
- v) Please also complete the module survey, which will be available from the Blackboard link on the last week of term. Completing the survey counts towards your participation mark.

Updates:

Project 3

ID	PI's (group -not individual)	Groups			
cgregg@tcd.ie	1/2/24	1	guoj5@tcd.ie	14/35	11
haughepa@tcd.ie	1/2/24	1	mahadevv@tcd.ie	14/35	11
ramasamv@tcd.ie	#N/A	1	tadepals@tcd.ie	#N/A	11
singha12@tcd.ie	#N/A	1	dpan@tcd.ie	#N/A	11
chenx14@tcd.ie	3/4/25/28	2	zhengzi@tcd.ie	15/36	12
samudras@tcd.ie	3/4/25/28	2	mehtah@tcd.ie	15/36	12
zli5@tcd.ie	#N/A	2	paranjik@tcd.ie	#N/A	12
kakkunuc@tcd.ie	#N/A	2	padinjav@tcd.ie	#N/A	12
xicai@tcd.ie	5/26	3	gurumurh@tcd.ie	16/37	13
bhatyes@tcd.ie	5/26	3	chenx14@tcd.ie	3/4/25/28	13
galaa@tcd.ie	#N/A	3	baskaral@tcd.ie	#N/A	13
ramachac@tcd.ie	#N/A	3	moorenn@tcd.ie	#N/A	13
krithivh@tcd.ie	7/17/27	4	thoralis@tcd.ie	18/38/43	14
georgesi@tcd.ie	7/17/27	4	panigraa@tcd.ie	18/38/43	14
shettyn@tcd.ie	#N/A	4	liowz@tcd.ie	#N/A	14
sunz2@tcd.ie	#N/A	4	paulausr@tcd.ie	#N/A	14
yint@tcd.ie	8/29	5	devendrv@tcd.ie	19/40	15
mandav@tcd.ie	8/29	5	surpurs@tcd.ie	19/40	15
sivapals@tcd.ie	#N/A	5	ramdurgv@tcd.ie	#N/A	15
sharifd@tcd.ie	#N/A	5	dilips@tcd.ie	#N/A	15
zliao@tcd.ie	9/30	6	liuy37@tcd.ie	20/41	16
yangh4@tcd.ie	9/30	6	akarora@tcd.ie	20/41	16
yeilovak@tcd.ie	#N/A	6	arnair@tcd.ie	#N/A	16
pnnarasim@tcd.ie	#N/A	6	khaunda@tcd.ie	#N/A	16
dingj1@tcd.ie	10/31	7	zhangt8@tcd.ie	21/42	17
lgong@tcd.ie	10/31	7	sajeevka@tcd.ie	21/42	17
samdanit@tcd.ie	#N/A	7	shoebm@tcd.ie	#N/A	17
dengyu@tcd.ie	#N/A	7	xuha@tcd.ie	#N/A	17
delmase@tcd.ie	11/32	8	anvara@tcd.ie	22/44	18
atripath@tcd.ie	11/32	8	sashaikh@tcd.ie	22/44	18
oreilp11@tcd.ie	#N/A	8	nasingh@tcd.ie	#N/A	18
duddupud@tcd.ie	#N/A	8	gopinatn@tcd.ie	23/6	19
dodiah@tcd.ie	12/33	9	hbabu@tcd.ie	23/6	19
ganesank@tcd.ie	12/33	9			
youyang@tcd.ie	#N/A	9			
mccare23@tcd.ie	#N/A	9			
ziaa@tcd.ie	13/34	10			
kusharip@tcd.ie	13/34	10			
liuy39@tcd.ie	#N/A	10			
yeilovak@tcd.ie	#N/A	10			