An Adaptive Resolution Scheme for Performance Enhancement of a Web-based Multi-User VR Application

Rishabh Pathak, Anderson Augusto Simiscuka and Gabriel-Miro Muntean

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Presenter: Anderson Augusto Simiscuka, Dublin City University

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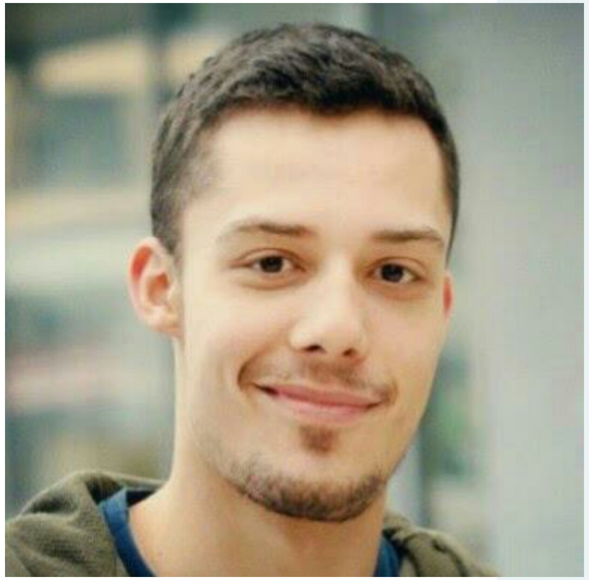
Introduction

Anderson Augusto Simiscuka



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SFI RESEARCH CENTRE FOR DATA ANALYTICS

Postdoctoral Researcher

Doctor in Electronic Engineering

anderson.simiscuka2@mail.dcu.ie

Motivation

- The performance of web-based virtual reality (VR) applications, such as ones built with A-Frame, can be affected due to the limitations of the CPU and GPU, especially in multi-user applications.
- It is important to understand and analyze these applications' performance under different scenarios, demonstrating how an increase in the number of users affects metrics related to VR quality of experience (QoE).
- A smooth frame rate is important in VR applications to prevent motion sickness.

Multi-user VR Application

- We propose a **multi-user** VR application developed using the A-Frame library, rendered as a 360° experience within a browser.

- The application allows users to watch a film in a synchronized manner, in a **virtual cinema room.**

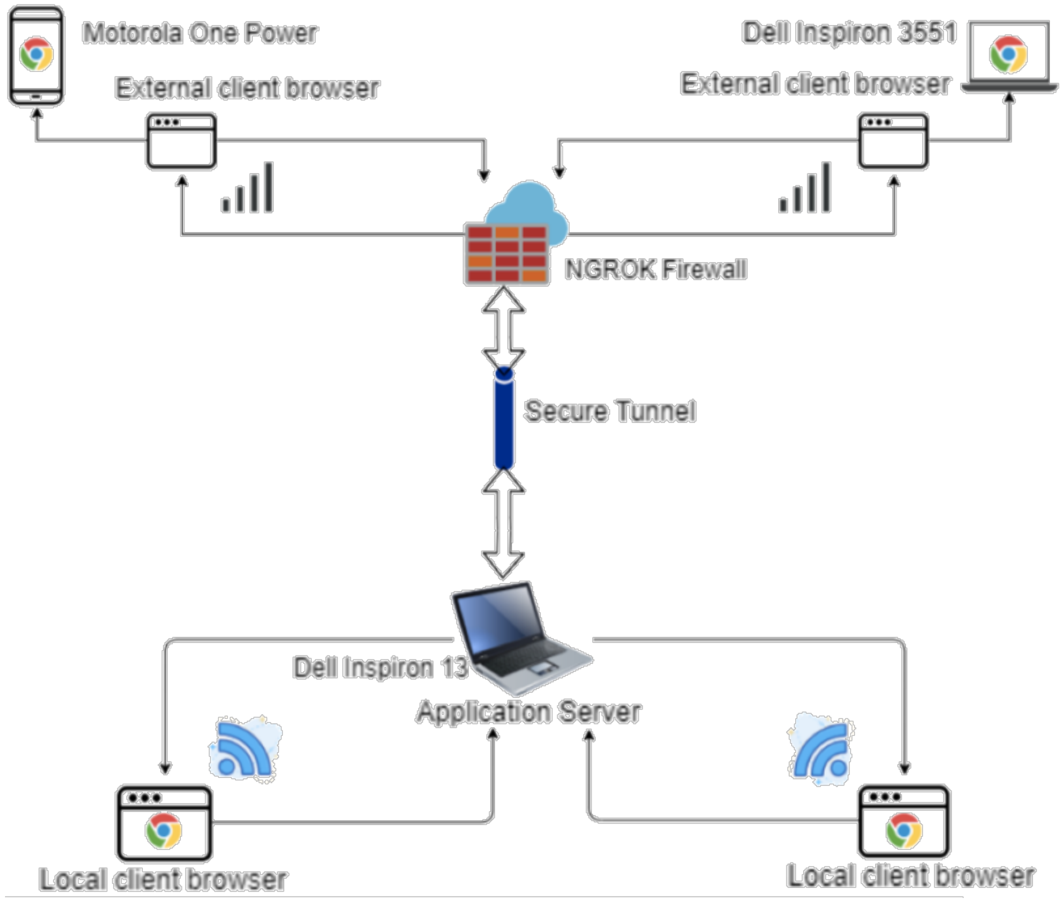
Multi-user VR Application

- The application employs a novel **Adaptive Resolution Scheme for VR (ARS-VR),** which improves VR applications' frame rate and frame latency on remote devices with limited processing and display.

- Users can move in the application, while WebRTC allows for voice chats. The library Networked A-Frame broadcasts synchronous playback to all clients.

VR Application Architecture

- The application uses a reverse proxy service called **ngrok** to expose the local application server to a firewall on the public internet using secure tunnels.
- Users that are not on the same network as the server can access the application by querying the link to the **secure tunnel**.
- Two laptops were used as the application **server** and a **client**. A smartphone was used to simulate another client from a different network than the server.



Adaptive Resolution Scheme for VR

- Once a connection is established, the server starts sending application data to the client and **ARS-VR** starts.
- The algorithm is deployed with **JavaScript** and it adjusts the resolution of the application by monitoring the frame rate.
- The numerator and denominator of the aspect ratio are multiplied with the frame rate to provide a **dynamic resolution.**

Algorithm 1: Adaptive Resolution Scheme for VR

```
while browser_window==open do
    Input: framerate; screen_width;
           device_pixel_ratio; window_height
    Output: maxCanvasSize
    Function greatest_common_divisor(w,
     h):
        var w = screen_width*device_pixel_ratio
        var h = window_height*device_pixel_ratio
        var ratio = screen_width/screen_height
        var gcd = greatest_common_divisor(w, h)
        var num = w/gcd
        var den = h/gcd
        return num, den, ratio, w, h
    Function Main:

    if ratio <1 then
        maxCanvasSize = {height: h/2, width: w/2}
    else
        maxCanvasSize ={height: framerate*den,
         width: framerate*num}

        return maxCanvasSize
    end
end
```

Adaptive Resolution Scheme for VR

- This is the main **contribution** of our work, as the VR application was built in order to test the approach.
- The approach can be applied to other **web-based VR** experiences as well.
- With the browser rendering the 3D scenarios in a lower resolution, the framerate gets closer to **60fps**, which makes the VR experience more pleasant to users.

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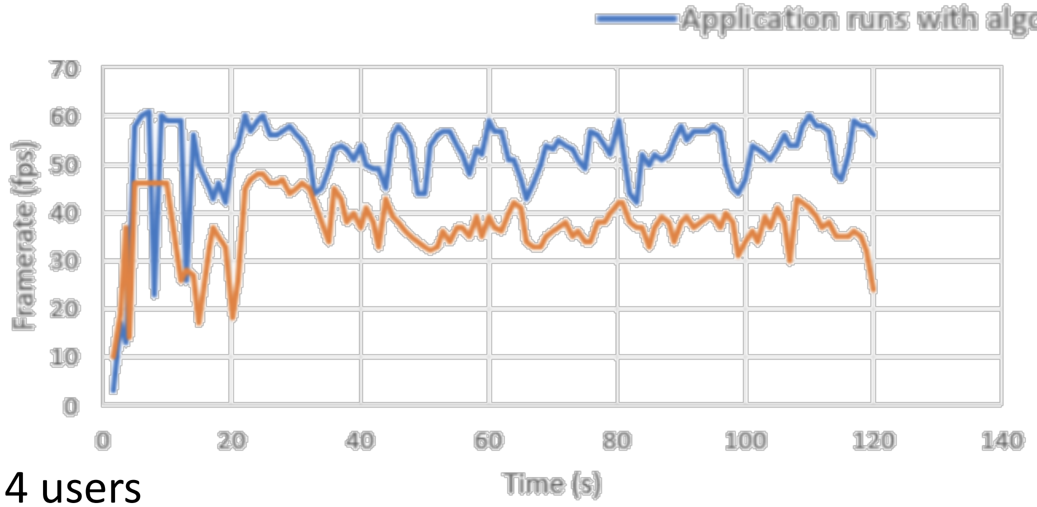
```

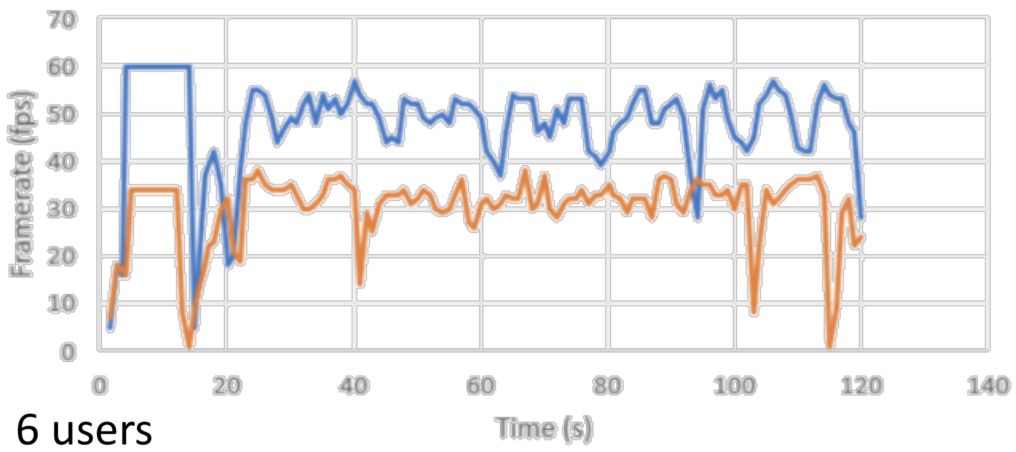
Performance Analysis

- Browser used was **Google Chrome.**
- The **frame rate** was collected for 120 seconds from the application with the algorithm ‘off’ (i.e. using the default 1920px resolution) and then with the algorithm ‘on’ (i.e. with dynamic resolution).
- Scenarios with **4, 6 and 8** simultaneous users were considered.

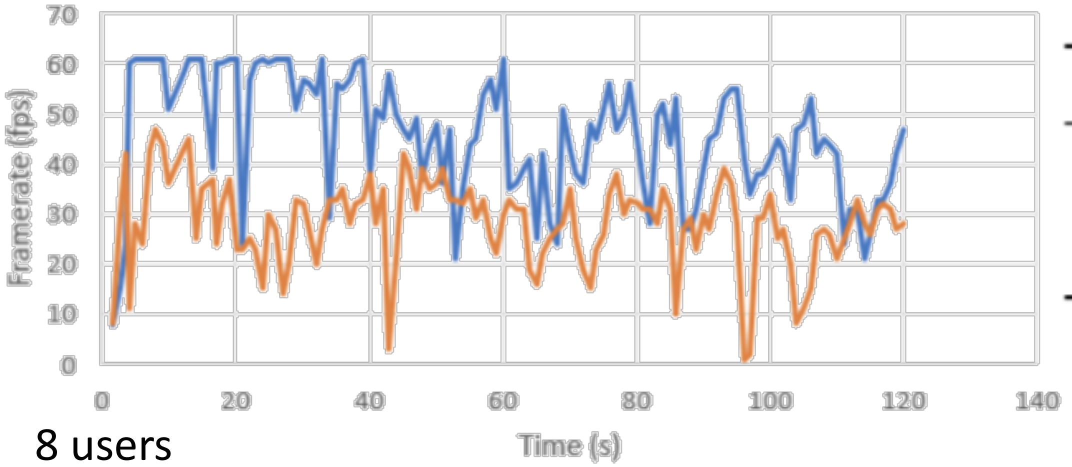
Performance Analysis - FPS



4 users



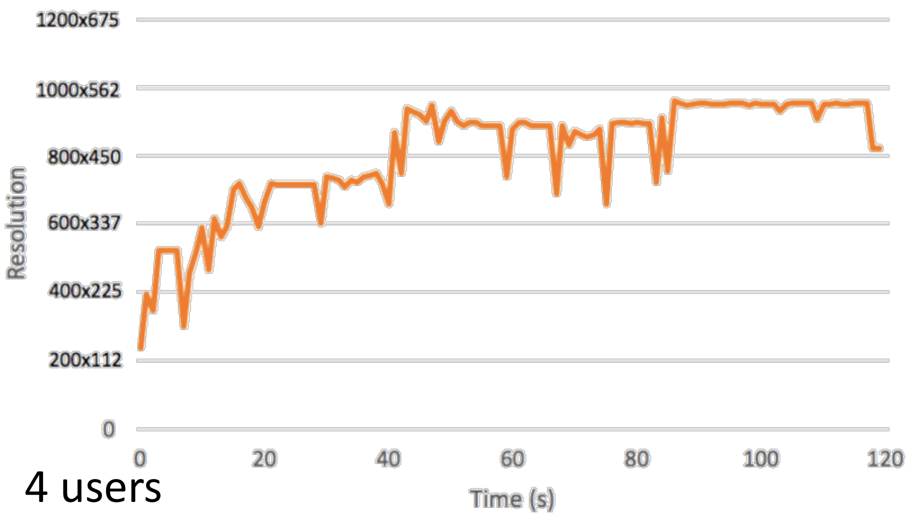
6 users



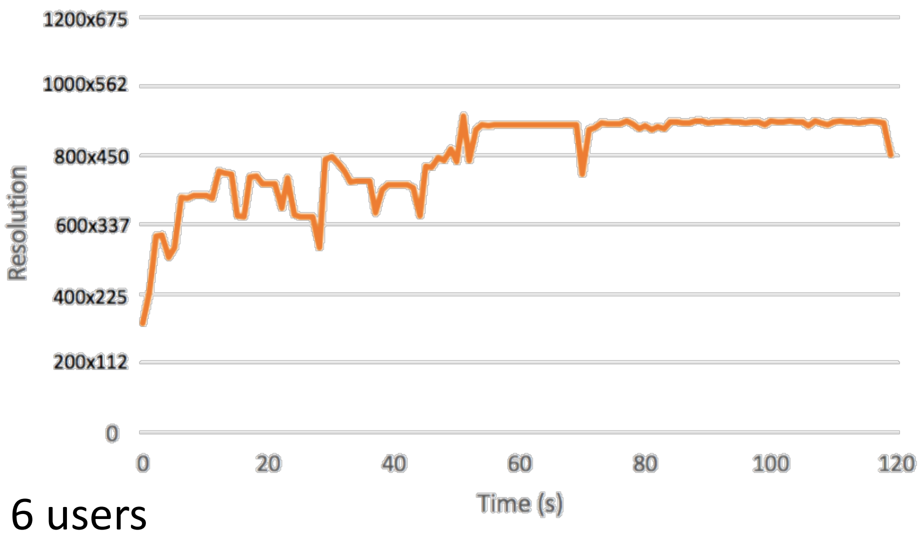
8 users

No. users	Avg. fps	Avg. fps-ARS	Avg. resolution	FPS loss reduction
4	36.65	50.94	806x453	23%
6	29.69	47.33	801x450	30%
8	27.94	45.23	667x375	28%

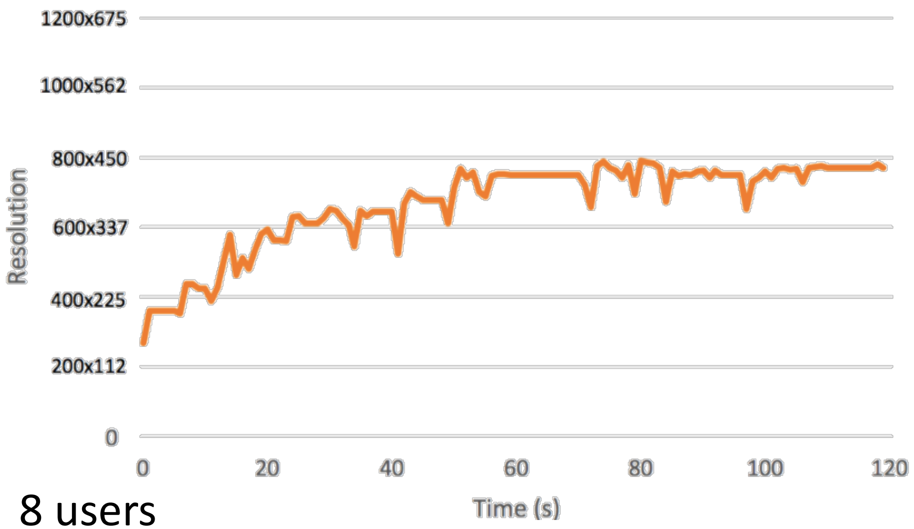
Performance Analysis - Resolution



4 users



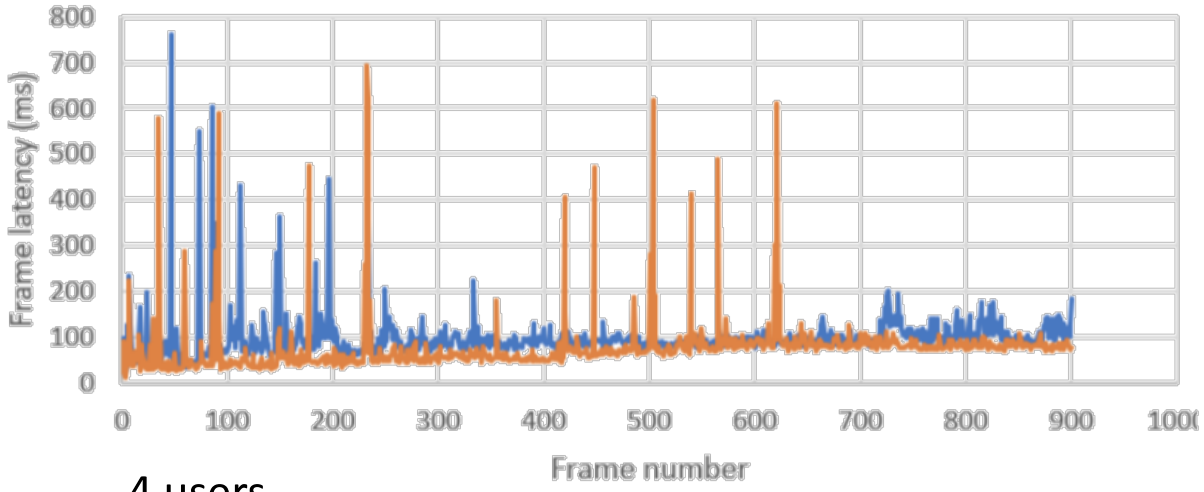
6 users



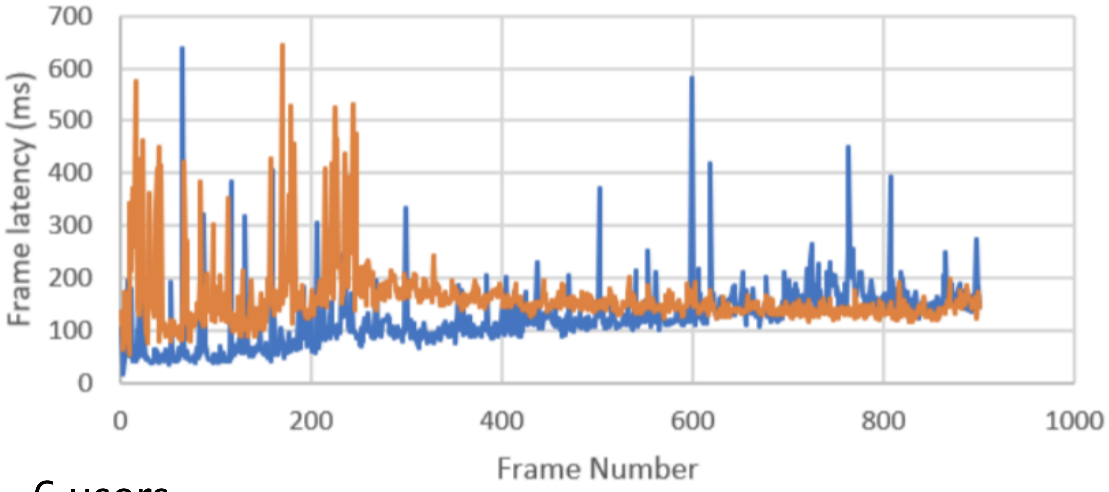
8 users

The resolutions, are on average 806x453px, 801x450px and 667x375px for the scenarios with 4, 6 and 8 users, respectively.

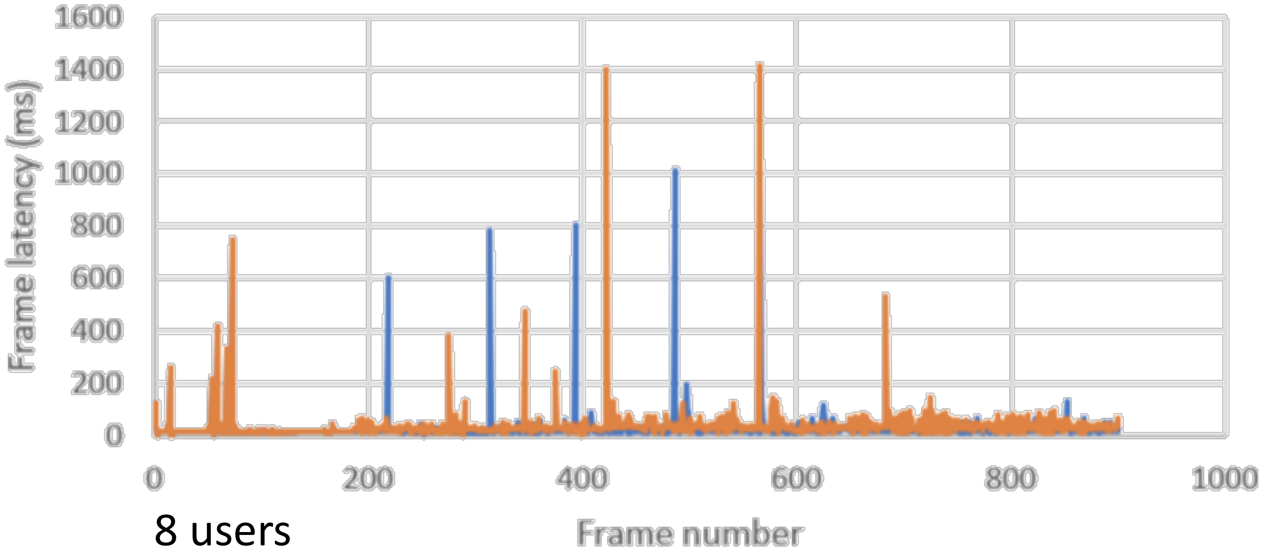
Performance Analysis – Frame Latency



4 users



6 users



8 users

- Frame latency peaks up-to 800 and 700ms in the case of 4 and 6 users, respectively.
- Avg. frame latency without the algorithm: approx. 90-100ms
- Avg. frame latency with algorithm: approx. 70-80 milliseconds.

Conclusion and Future Work

- The A-Frame **browser-based multi-user VR application** can be rendered on remote devices with limited processing and display features.
- The **ARS-VR algorithm** was also introduced, aimed at improving VR performance in terms of frame rate and frame latency on such devices, with the dynamic adaptation of the visuals resolution.
- ARS-VR significantly **reduces the FPS loss** in the scenarios of 4, 6, and 8 simultaneous users by 23%, 30%, and 28%, respectively.
- Future work will improve the algorithm to **support devices** with different screen height and width ratios. **Other user applications**, such as video conferencing in A-Frame and other device types can also be studied.

Thank you for your attention

Anderson Simiscuka, Dublin City University

www.traction-project.eu

Anderson Simiscuka (DCU)
anderson.simiscuka2@mail.dcu.ie
www.eeng.dcu.ie/~pel

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