

# **USE OF THE PSEUDO-RANDOM URBAN FEATURE ENTITY SERVER (PRUFES) TO EVALUATE URBAN APPLICATIONS**

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## **Abstract**

The United States Army is transforming into a force that is lighter, more rapidly deployed, and better suited to the needs of a changing operational setting. This transformation is necessary to maintain the world's most dominant military force in an ever-changing battlefield. Whereas previous wars have been fought in vast open spaces, today's missions require the soldier to fight in urban and suburban areas as well as uninhabited areas. Military Operations in Urban Terrain (MOUT) and Military Operations in Built-up Areas (MOBA) require specific training in the tactics and techniques of such a mission. The most common method of training for urban operations is by practicing in small mock towns; however, these sites are costly to develop, instrument, and maintain. In addition, MOUT sites become predictable to warfighters once they have participated in several training exercises. To combat this problem, the US Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC) has developed a simulation tool that provides an urban/suburban sprawl environment.

In the past, if an urban/suburban sprawl area were required for a simulation, every entity in the defined area had to be created within the large, static "neighborhood." The Pseudo-Random Urban Features Entities Server (PRUFES) allows for real-time generation of a cultural feature set that realistically represents a geo-typical terrain. As the server monitors the movements of a user, it populates an existing terrain with a selected cultural features set within the line of sight of the user. The particular cultural features set used for this PRUFES experiment contains three each of small, medium, and large houses, including the interior of each house that can be generated as needed. Each yard contains various combinations of trees, fences, and cars. The feature entities are repeatable, but variable in combination, placement, and appearance. The population of the terrain is random, but is based on a chosen point of origin. The PRUFES server distributes these features as objects to client machines across High Level Architecture (HLA) or Distributed Interactive Simulation (DIS) interfaces. PRUFES has the capability to create a practically infinite sprawl area without overburdening the client machine.

This paper discusses the three-week PRUFES experiment performed by a Systems Engineering student at the United States Military Academy. The purpose of this experiment was to test the capabilities of the server and provide early soldier feedback into the appropriateness of the server as a training aid and to investigate potential urban warfare applications. The experiment contained a homeland defense scenario that required the user to move through a suburban sprawl area, searching house-to-house for a hidden suitcase that represented a threat such as an explosive device or chemical agent. The collected data and resulting feedback from the experiment will be beneficial for future improvements to PRUFES.

## **Biographical Sketch**

Polly Ann Cayson is a project engineer for the US Army AMRDEC at Redstone Arsenal, Alabama, in the Advanced Prototyping, Engineering and eXperimentation (APEX) Lab. She earned a BS in Industrial Engineering from Mississippi State University and a MS in Management from Florida Institute of Technology. Her current focus areas in the APEX Lab are urban simulation and constructive simulations analysis.

Clinton T. Speegle is a third year cadet at the United States Military Academy at West Point. He is a Systems Engineering major and is scheduled to graduate in May of 2003. He was assigned to AMRDEC for his Academic Individual Advanced Development through the Department of Systems Engineering.

Bobby Wright is a computer engineer for the US Army AMRDEC at Redstone Arsenal, Alabama, in the Advanced Prototyping, Engineering and eXperimentation Lab. Prior to his current efforts developing cultural feature sets for PRUFES, Mr. Wright worked at the Tank, Automotive, and Armaments Command in Warren, Michigan. He earned a MS degree in Electrical and Computer Engineering from the University of Michigan.

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## Introduction

The United States Army is transforming into a force that is lighter, more rapidly deployed, and better suited to the needs of a changing operational setting. This transformation is necessary to maintain the world's most dominant military force in an ever-changing battlefield. Whereas previous wars have been fought in vast open spaces, today's missions require the soldier to fight in urban and suburban areas as well as uninhabited areas. Military Operations in Urban Terrain (MOUT) requires specific training in the tactics and techniques of such a mission. The most common method of training for MOUT operations is by practicing in mock towns; however, these sites are costly to develop and maintain. In addition, MOUT sites become predictable to soldiers once they have participated in several training exercises. To combat this problem, the Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC) has developed a simulation tool that provides an urban/suburban sprawl environment.

In the past, if urban/suburban sprawl were required for a simulation, each house, tree, car, or mailbox had to be created in a specific spot within a large, static "neighborhood". The Pseudo-Random Urban Features Entities Server (PRUFES) generates neighborhoods "on the fly." As the server monitors an incoming user, it populates an existing terrain with a cultural feature set within the line-of-sight of the user. The cultural feature set can be anything from the warehouse district in a large city to the geo-typical United States suburb used in this experiment. This particular cultural feature set contains three each of small, medium and large houses, including the interiors. Several textures and colors exist for the houses. Each yard can contain various combinations of trees, fences, and cars.

The purpose of this experiment was to test the capabilities of PRUFES and to provide soldier feedback regarding the appropriateness of the server as a training aid. The experiment was based on a homeland defense scenario where the user was required to move from house to house within a suburban sprawl area to find a suitcase. The feedback from this exercise promises to be helpful for future improvements to the system.

## Experimentation

### Design

The initial phase of the experiment was to develop a scenario and the methodology for completion of the experiment. The scenario was used to provide boundaries for the experiment and basic information for future runs of the same type experiment.

The scenario (Appendix A) was modeled in a fashion similar to that used in other training operations conducted by the United States Army and, particularly, the United States Military Academy, Department of Military Instruction. The scenario allows for multiple variables to be changed by the Observer/Controller (OC) of the experiment. Variables included weather condition, MOPP status, line-of-site, and distance to the target. Following completion of the scenario, a run matrix (Appendix B) was developed to outline the changing variable conditions for each trial of the experiment.

### Research

In order to ensure maximum realism in the experiment, research was conducted on the methods used for bomb detection and searches. The goal of this phase was to learn the actual procedures used by law enforcement authorities when searching for a hazardous device. An instructor and defense tactics expert at the Huntsville Police Academy (HPA) provided the experiment a copy of the HPD 401-7, the standard operating procedure for a law enforcement agent of the city of Huntsville, Alabama, responding to a bomb treat. An experimental parameter of a 1000-foot search radius was established from HPD 401-7. This information helped to provide legitimacy to the distances that would be traveled over the course of each run. The HPA officer stated that the rate at which a well-conditioned individual can conduct a search while in a Hazardous Materials (HAZMAT) suit is only 33 meters per minute. The individual can only move a short distance before he or she is too exhausted to continue. Given this information, it was decided that a HAZMAT suit would not be included in the experiment, but would instead be replaced with a

traditional Army chemical and biological protection (MOPP) suit.

Online research revealed that the vast majority of special bomb task forces attend the Federal Bureau of Investigation's (FBI) Hazardous Device School (HDS) at Redstone Arsenal, Alabama. An agent at HDS provided information on the tactics that are used in finding a hazardous device. He also provided the experiment with literature from the Department of Alcohol, Tobacco, and Firearms (ATF) training manual and from the HDS training manual. However, this material is considered sensitive in nature and therefore cannot be included as an appendix. The information gathered from this source was used to develop tactics that would closely resemble actual tactics used by a bomb task force or Explosive Ordnance Disposal units.

### **Implementation**

Cadet Clinton Speegle is a third year cadet at the United States Military Academy at West Point. He is a Systems Engineering major and is scheduled to graduate in May of 2003. He was assigned to AMRDEC for his Academic Individual Advanced Development through the Department of Systems Engineering. As the user in this experiment, Cadet Speegle conducted four trial runs before the record runs began. The purpose of the trial runs was not only to provide user familiarization, but also to search for any imbedded faults that would hinder an accurate outcome from the experiment. The goal of the exercise was to locate a silver suitcase. Trial runs revealed that the suitcase was not visible in houses that are built on a crawl space. A simulation developer for PRUFES determined that the solution to this problem was to float the suitcase at approximately 1.5 meters above the ground. Although a floating suitcase is unrealistic, it proved to be sufficient for the purposes of this experiment.

Using the run matrix as a guide, each run situation was set up with a particular set of variables. At the beginning of each run the user was briefed on initial conditions. He was provided a map of the area (Appendix C) and a starting point, along with the direction he was facing. He was also provided with the sector of the map containing the suitcase. On short distance runs, the suitcase was located within one neighborhood. Although longer distance runs could include searching up to four neighborhoods, the OC usually provided more detailed clues that helped limit the search to fewer houses within the sector. A normal run would often involve between fifteen and fifty houses.

The user moved through the virtual environment using a desktop manned simulator of a dismounted infantry figure. He searched from house-to-house utilizing the techniques defined by the consulted HPA and HDS experts. Each scenario restricted search time to one hour based on the scheduled detonation time of the bomb. If the user successfully reached his goal, he moved to the nearest major intersection in accordance with the scenario. Once he reached the intersection, time was stopped. If the search were unsuccessful, it was terminated after one hour. Regardless of the result, the number of houses searched and the duration of the search were recorded.

### **Results**

The results of this experiment were two-fold: experiment duration data (Appendix D) and user feedback. The duration data, when plotted versus the number of houses searched, is linear with only a few exceptions. User feedback will be discussed in the recommendation paragraph.

### **Recommendation**

PRUFES is a well-designed simulation; however, like all programs early in development, it needs some fine-tuning. For example, in one house an entity, in this case a tree, was found in the living room. In another cases, a fence was inside a house. Simply moving the intruding entity to another location solves this problem. These types of anomalies have been cleaned up throughout the design process. Running future experiments will help double-check for similar problems.

The most difficult obstacle to the user in this experiment was determining his orientation. Aside from the start direction provided to the user, no further navigational guidance was provided by the OC. Skills learned in military training were the primary tools available to the user throughout each run while civilians must rely primarily on terrain recognition. Because a map was provided, the street names did offer one terrain feature needed for movement through the neighborhood. In the future, contours of terrain might prove beneficial for movement and realism purposes. Another alternative could be the inclusion of a compass in the client simulation. This feature would provide the user with a sense of direction at all times, particularly under low-light/low-visibility conditions. Ideally, the simulation could include both terrain contours and a compass to provide the most realistic navigation for training purposes. Another easy reference would be to name all north-south running roads as avenues and all east-west running

roads with street names. A user would be able to determine his orientation by simply finding a street sign.

Orientation inside of the houses was also difficult. The user was forced to focus his eyes on the floor in order to move through the house. Because walls do not provide a fixed boundary at this time, watching the floor was the only effective way of moving without going through walls. This problem could be fixed with future upgrades to the simulation. However, if this is not possible, changes in wall texture and color would keep the user from becoming disoriented. A small black line along the corners of walls would help to identify room boundaries.

Rate of movement does not affect the search rate of houses. The time of movement between houses was significantly reduced when the rate of movement was higher. However, once inside the house, the user found that the higher rate of movement actually hindered the effectiveness of the search. "Slow is smooth and smooth is fast" is appropriate in describing the relationship between movement rate and search rate. Ideally, the client simulation would be able to change between rates of movement when the user enters or leaves a building.

During the experiment, the user moved through the neighborhoods using a joystick. He determined that a change in the configuration of the joystick that would allow the user to move from side to side while still looking forward would be helpful. The ability to look left and right is necessary when operating the robotic feature; however, the inability to move right and left while looking forward made some movements with the Dismounted Infantryman awkward.

The ability to move along the Z-axis would provide added realism to the simulation. Multi-level buildings are essential for training in a MOUT environment. The

future of PRUFES may include fire fighter and police training simulations in addition to the potential uses by the military. The ability to move up and down stairs would be an asset during training exercise using PRUFES.

Added variable conditions such as rain and snow are needed to provide the Army with the necessary environments for training. Nighttime conditions are paramount to creating an effective simulation tool. A Night Optical Device view would prove beneficial to multiple facets of Army and civil training. Other operational environments that should be considered: warehouse districts, shopping malls, high rise buildings, third world cities or villages, jungle hamlets, trailer parks, schools, apartment buildings, and airports.

The ability to link elements from team size (4 men) to platoon size (40 men) is another element essential for the success of PRUFES. Ground warfare focuses on the idea of "shoot, move, and communicate." Rarely will the soldier find himself doing a mission alone, so the ability to link multiple users to the same server in an interfacing environment is an important aspect of a simulation tool. This also applies to fire fighters and search and rescue teams. The ability to include operation vehicles and force-on-force simulations in PRUFES should be evaluated in future experiments.

## **Conclusions**

Today's Army is looking for ways to provide quality training at minimal cost to its soldiers. PRUFES provides a varying terrain that will provide the soldier with a minimal predictability simulation. Although not ready to field at this time, PRUFES will provide the Army with an effective simulation tool that will ensure worthwhile training at minimal operational costs.

## Appendix A

### Scenario

**Location:** Housing on a United States military base that is representative of a prototypical American neighborhood.

**Objective:** Locate an explosive device that has been placed inside a residence.

**Scenario:**

A terrorist group has penetrated the security elements of Redstone Arsenal, Alabama. This force is made up of para-military Cortinians who are upset that the United States did not allow Cortinia to join in the International Space Station (ISS) efforts. The members of the group have overrun security forces at the Marshall Space Flight Center and are holding several scientists of the ISS hostage.

You are a soldier in the military police unit stationed at Redstone Arsenal. You are on the scene at the Marshall Space Flight Center in support of a Task Force dealing with hostage negotiations. The Provost Marshal's office receives a call from the wife of an officer who lives in the officer housing area. She states that a suspicious individual, dressed in clothing similar to the terrorists she has seen on TV, was seen snooping around the officer housing area. He was carrying a silver suitcase that may contain an explosive device. This group has been known to use chemical agents in past operations; therefore, you may choose to wear Nuclear, Biological and Chemical (NBC) protective gear to safeguard yourself from a pending NBC threat.

Your commander cannot afford to release more than one person from the hostage scene. He designates you as the individual to go to the area to investigate. The officer's wife who placed the call has already evacuated the area. Your job is to search the area thoroughly and find the suitcase before it detonates. You will not remove the device, but rather move it to the nearest major intersection so that the Explosive Ordinance Disposal unit responding to the call can easily find you and defuse the device safely.

**Variables:**

Range to Target: 200m, 400m, 800m in walking distance.

Start Point Line of Site: Major intersection or cul-de-sac.

Weather Conditions: Fog or clear.

Route to Target: Varied among three routes to prevent the user from following a familiar route.

MOPP Status: MOPP 5 involves donning the entire protective suit. This would slow down the user's movement and the amount of area that he could search effectively. MOPP 1 involves minimal protective gear and would allow the user to travel as quickly and for as long as time allows.

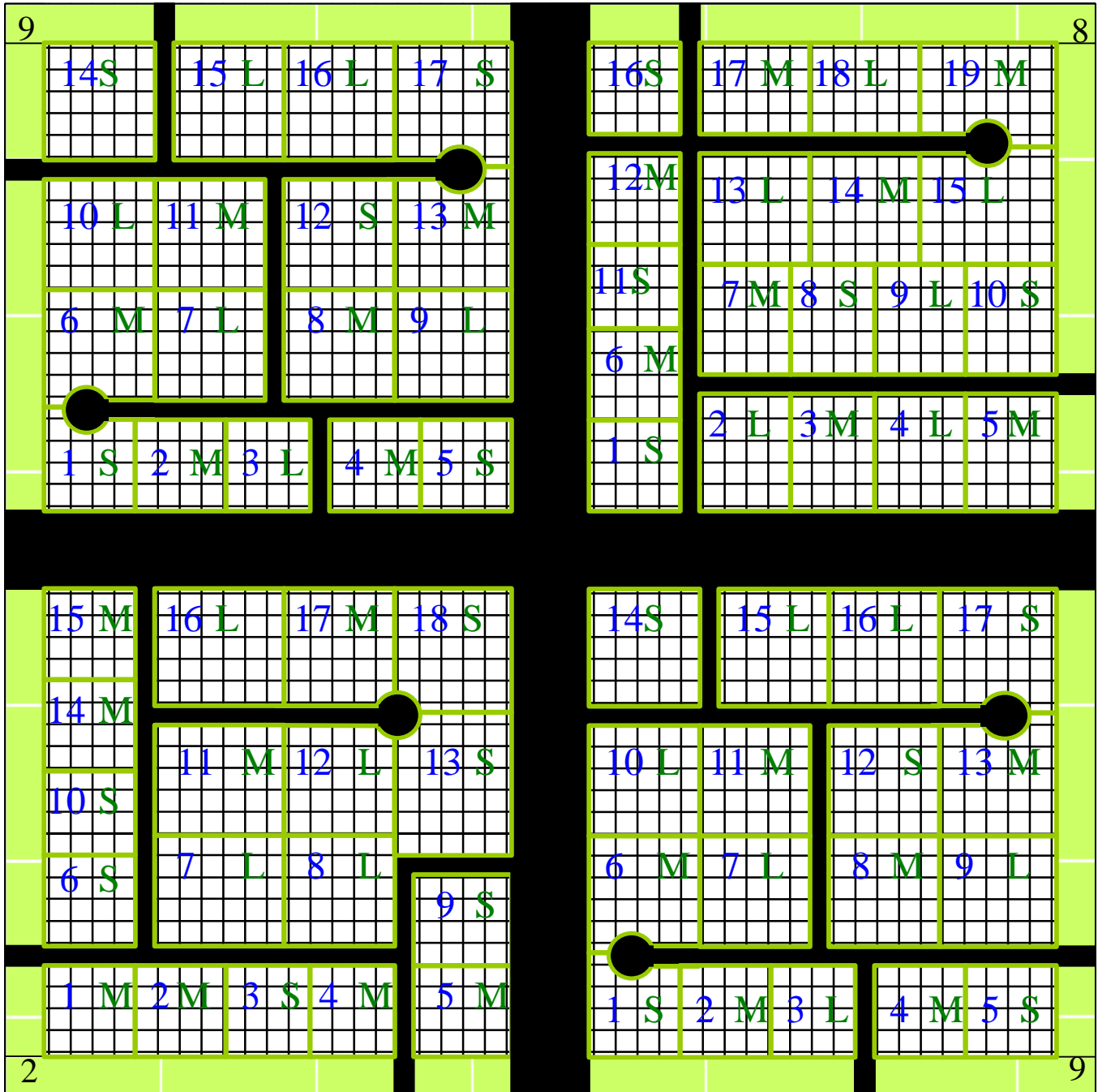
## Appendix B

### PRUFES Experiment Run Matrix

Scenario	Range	Start Position LOS	Weather	Route	MOPP Status
1	200m	Major Intersection	Fog	1	5
2	200m	Cul-de-Sac	Fog	2	5
3	200m	Major Intersection	Clear	3	5
4	200m	Cul-de-Sac	Clear	3	5
5	200m	Major Intersection	Fog	1	1
6	200m	Cul-de-Sac	Fog	2	1
7	200m	Major Intersection	Clear	3	1
8	200m	Cul-de-Sac	Clear	3	1
9	400m	Major Intersection	Fog	1	5
10	400m	Cul-de-Sac	Fog	2	5
11	400m	Major Intersection	Clear	3	5
12	400m	Cul-de-Sac	Clear	3	5
13	400m	Major Intersection	Fog	1	1
14	400m	Cul-de-Sac	Fog	2	1
15	400m	Major Intersection	Clear	3	1
16	400m	Cul-de-Sac	Clear	3	1

# Appendix C

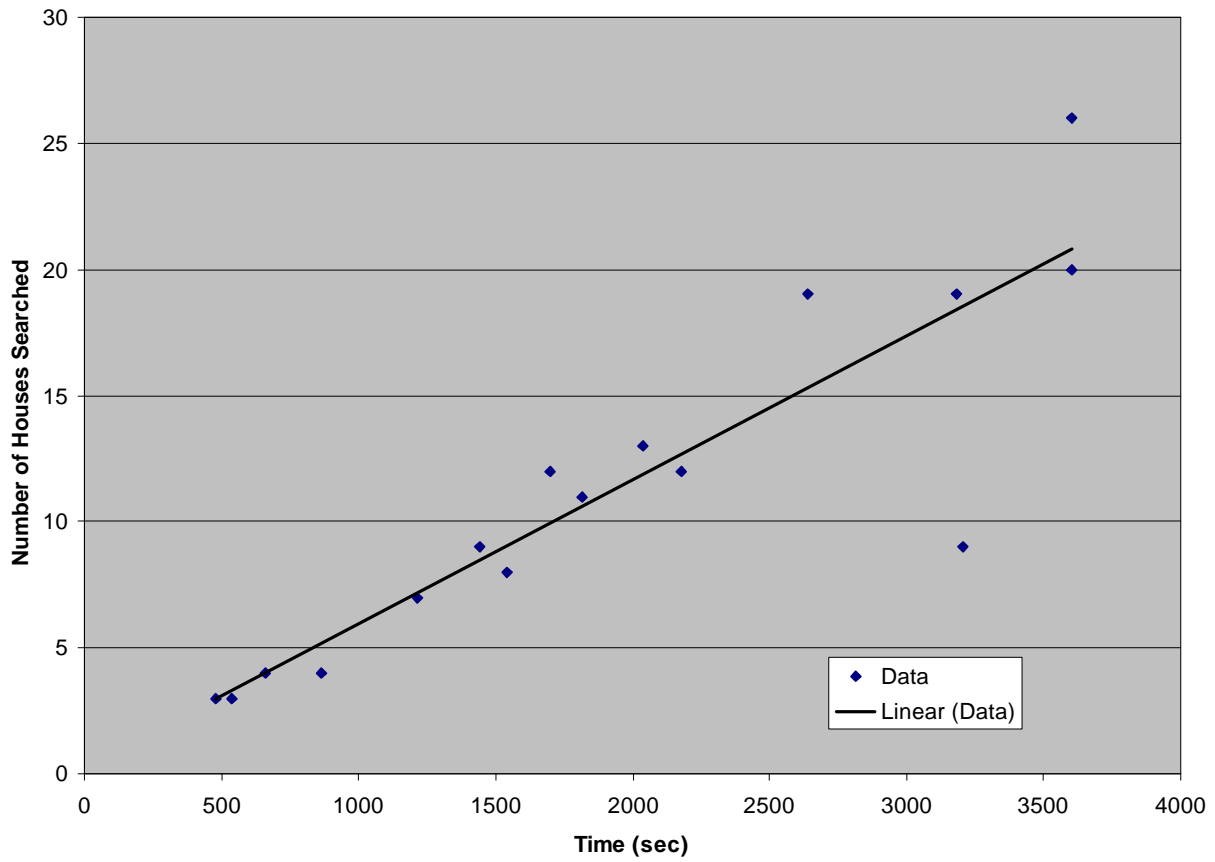
## Neighborhood Map



# Appendix D

## Time Data

Search Rate



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