Digital Grid Gems in Houdini Virtual Reality

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Abstract: The purpose of this paper is to show how Houdini Sidefx can be leveraged to develop “grid” gems. Here we start with a simple Houdini grid node and explore how this node can result in developing multifaceted scene views for virtual reality. With the advent of COVID-19, Virtual Reality has revolutionized academic world whether it is in-class teaching, online teaching, participating in the conferences in-person, or remotely, individual zoom meetings and all that. In addition, it led to innovation and development of new courses eBooks replacing printed books. Virtual reality was mainly in the realm of film and entertainment industry. It is changing the education culture altogether, and it is becoming the supporting pillar in every aspect of life. With this paper we show how immersion results in innovation of applications and how complex scenes can be created with a simple tool.

Keywords: virtual reality, user interface, animation, node

Introduction

With the advent of COVID-19, Virtual Reality has revolutionized academic world whether it is in-class teaching, online teaching, participating in the conferences in-person or remotely, personalized face to face meetings remotely and much more. In addition, it pointed to innovation and development of new immersive course material in terms of eBooks and video Books replacing printed books. Virtual reality was mainly in the realm of film and entertainment industry. It is changing the education culture altogether, and it is becoming the norm in every aspect of life [1].

Not only that, the diverse modalityalso continues to improve communication amongst a large variety of areas, engineering, industry, natural phenomena.For example, the tornados research at Missouri University of Science and Technology, natural disaster hazard identification at South Dakota School of Mines and Technology highlight the enormous improvementfrom traditional to virtual reality training outcomes [2]. The advantages include learning curve reduction in complex subjects, learning material retention in long term memory and learner confidence building. VR creates pretty pictures for visualization and immersive learning environment [3]. For example, in the case of natural disasters, it helps in motivating the audience to be proactively ready against hazards and how to be resilient to destruction resulting from tornados and hurricanes. VR leads to innovation in many research areas.

Houdini SideFX

There are several softwares to develop and deploy virtual reality projects. Houdini sidefx is a software of choice because it is procedural, flexible, enhance able without developer involvement. It is free for the beginner and there is enormous support for the learner. There is more than enough educational material in terms of tutorials for the solo learner.

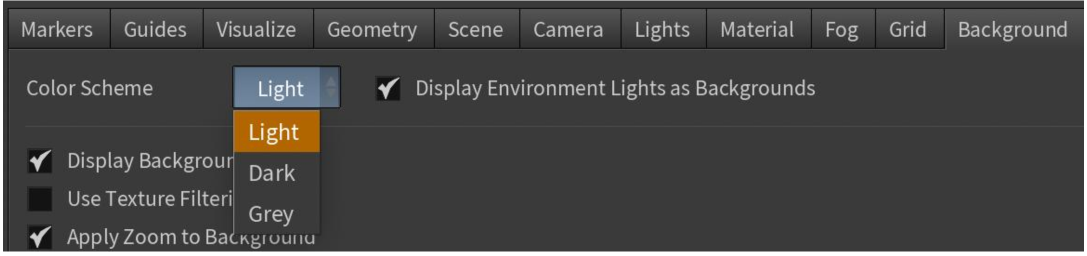
First Houdini user interface

The default Houdini interface consists of three panes. Sceneview pane displays the objects, network pane shows the workflow network, and parameter pane is for editing the attribute values [4]. Three paneinterface is not rigid, but sufficient for small applications. It can be fine-tuned to accommodate complex workflow network. In fact, the users may tweak it to replace default interface, then one hascustom interface automatically displayedevery time. Here is compact and comprehensible description of interface for the beginner and experienced.

The first step to understandinterface is to know how to navigate the interface before developing any application.Before an applicationis deployed for use, it mayalso be desirableto identify the source of application software.Houdini can be easily adapted to include developer identification source and logo. We start first for visually recognizing the objects in the sceneview.

Screen Background

Many times the color of objects displayed is similar to the color of sceneview making it difficult to isolatethe view from the object. The sceneview background color can be easily improved to make the display crystal clear. To accomplish this in Houdini, type d in sceneview, from the drop down dialog menu select background tab ,then from color scheme tab, change the sceneview background to desired color (from lighter to darker), to be able to see the model, see Fig. 1 below.



Color Scheme: Light

☑ Display Environment Lights as Backgrounds

☑ Display Backgrour

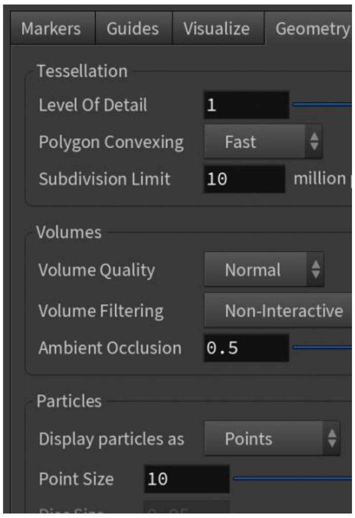
□ Use Texture Filteri

☑ Apply Zoom to Background

Figure 1. How the sceneview background color is modified for better visualization of objects.

Screen Pixel Point Size

Sometimes the images displayed on the sceneview are quitetiny in size that makes it difficult for thehuman eyes to identify them. To enlarge the pixel point size in Houdini, typed in sceneview, select geometry tab, then at tab point size, change the pixel point from 3(default) to say 10, see Fig. 2. Then the modelled points become large enhancing the visibility of model.But, many times you want the size to be small, e.g. work with rain drops, wind, hurricanes etc.



Tessellation

Level Of Detail: 1

Polygon Convexing: Fast

Subdivision Limit: 10 million

Volumes

Volume Quality: Normal

Volume Filtering: Non-Interactive

Ambient Occlusion: 0.5

Particles

Display particles as: Points

Point Size: 10

Figure 2. How to change the pixel point size for better visibility,

Pane Management

For navigation, it is necessary to manage panes, size of any of the three panes can befine-tunedto full window size by clicking on the little white square in the top right corner of a pane, see Fig 3.

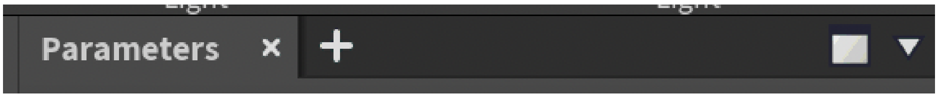
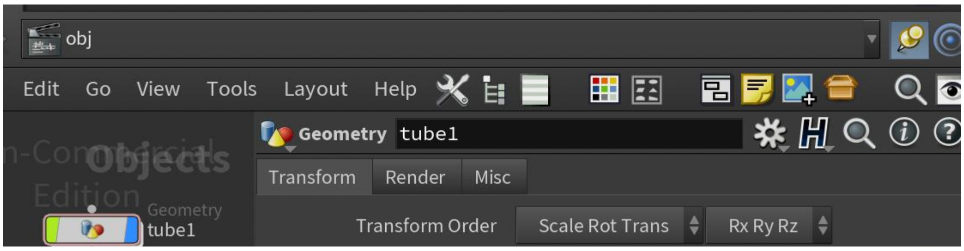


Figure 3. Expanding and shrining the pane to full screen



Geometry tube1

Transform Order: Scale Rot Trans, Rx Ry Rz

Figure 4. Parameter pane for network tube object is removed or activated with pressing “p” in the networkpane.

A pane can be removed by clicking symbol "X" in the toolbars, see Fig 3. If you remove the parameter pane, all the space is allocated to network pane. Now in the network pane, one can see the network workflow comprehensibly. Typing "p" in the network pane brings the parameter pane backto network pane for editing attribute values. Typing "p" in the network paneactivates/deactivates the parameter pane, see Fig 4. To customize the desktop: left mouse button (LMB) click on desktop in topmost toolbar brings down drop down list (DDL) in which there is desktop manager tab, creates desktop, save, accept, creates desktop. Now go to newly created desktop, rename it, make changes to desktop, accept. Any desktop view can be saved by using the desktop manager. It can be referenced at willor can be made default current desktop, see Fig. 5.

Figure 5. Desktop manager in toolbar desktop to create custom desktop, e.g. Chaman

Magic of Houdini Grid Node

In Houdini, everything is a node,whether it is data or operation. A node can be a class, anattribute,a data object, and an operation function. GUIs make it easy to create and maintain projects visually. Houdini programming is GUI based,drag and drop programming replaces formal code-based programming. One can design and develop a complete project with Houdini sideFX software without the need to write a single line of text-code. Houdini provides a digital version of real environment; it allows you to explore and exploit new concepts you have never envisioned. Houdini features immersion: usability, manageability, efficiency,effectiveness, knowledge retention. Itmakes updates easyand transparent. Moreover, it is extensible allowing the user to add user created libraries by creating Houdini Digital Assets, thus enabling the user you to easily create, edit, scale, embed, track across the deployment.

A node can be created in 5 different ways: 1. Two ways from toolbar by left mouse button (LMB) click for placing the node at a custom location in sceneview or ^LMB click for alignng the node center with the sceneview origin, (3) three ways from network pane, right mouse button (RMB) click drops down the nodes list (DDL) , then selection from DDL or typing in the top textfield or selecting from history activates the selected node. The resulting node is displayed in sceneview, its tab appears in the network view, editing node properties occur in the parameter pane.

Node Processing for creating custom objects

Datanodes often use transform nodeexplicitly or implicitly. Most of the time, transform node is used, and as a consequence, implicitly built in the other nodes. The attribute values are updated by "Type in"value or "copy and paste relative reference parameters", explicitly visible thumb slider, implicitslider (ladder slider), reference parameters, or dynamic values using somefunction involving frame number $F corresponding to animation playbar.

Evergreen nodes

For custom visualization, one can transform the camera view depending on sceneview layout. It is preferable to stay in the current desktop view during the whole process. Normally, any changes may be made in parameter pane rather than sceneview.

Identification Node Creation Creating nodes can be accomplished with any of the methods, it is quite easy once you start using it. **The font** node is used to display text in the sceneview. To place it at the right place, we use the implicit transform (rotate, translate, scale) to move it to desired location. It is useful to identify the resource developer, see Figure 6.

The Font node is used to include the description of the organization.For any file location reference, a click on arrow on the right of textfield in parameter pane brings drop down list (DDL) of options, scroll the directory path tofilter the path to where the file is. Like font, we apply transform to place the logo and picture information at the desired location.To paste animage on an object, it is as easy as creating a uvQuickShade node for the image, see Fig 7.

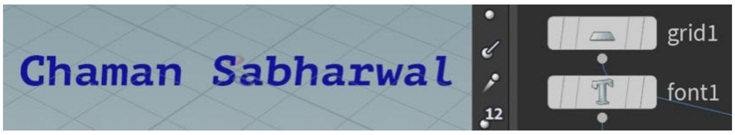


Figure 6. Grid node displaying text with Font node scaled and colored.

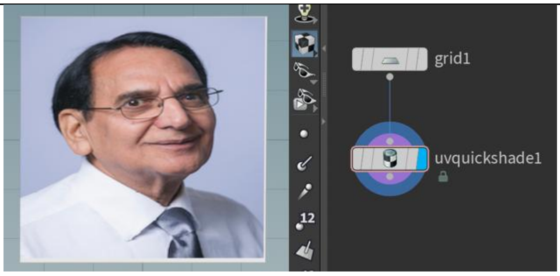
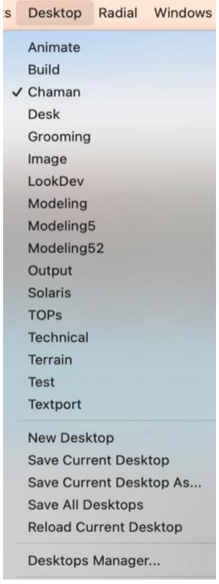


Figure 7. Grid node displaying image with uv Quick Shade node

The Animation Magic

Animation is the hall mark of virtual reality. Mostly, animation is built in Solver nodes. Custom animation is created with $F and associated functions to create special effectse.g.windeffect, earthquake etc. Animation is displayed both interactively and automatically with the use of animation playbar.



PolyExtrude on PolyExtrude

Grid Node and Artistic Highrise Buildings: A grid node createsthe following two buildings by simply pulling the grid upwards. In the first case, Fig 8.polyextrude‘s inset attribute creates the effect of windows in the highrise building, in the second case Fig 9, polyextrude’s twist attribute creates the effect of twisted towers.

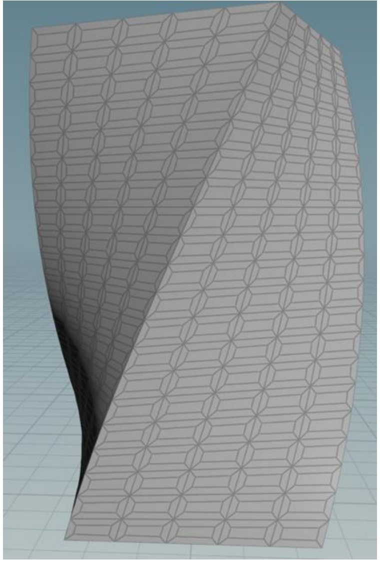


Figure 8 Windows highrise

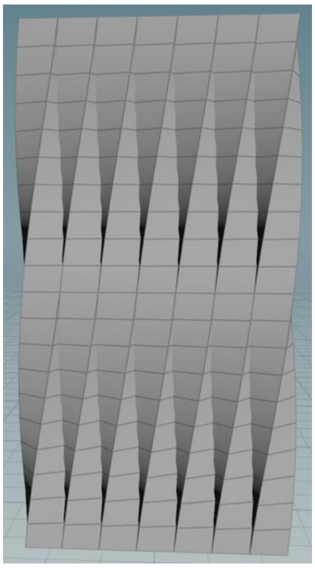


Figure 9 Twisted towers highrise

Grid Shatter

Here grid node iscreated and a little thickness is added by polyextrude node. Two identical copies, A and B, are placed next to each other. Normally Boolean node applies constructive solid geometry operations union, intersection, A minus the other B and vice versa, B-A on the two rigid body object. Houdini has an additional operation called "shatter". If this operation is used, then it separates the union, A∪B, into three mutually exclusive parts: A-B, B-A, and A∩B.

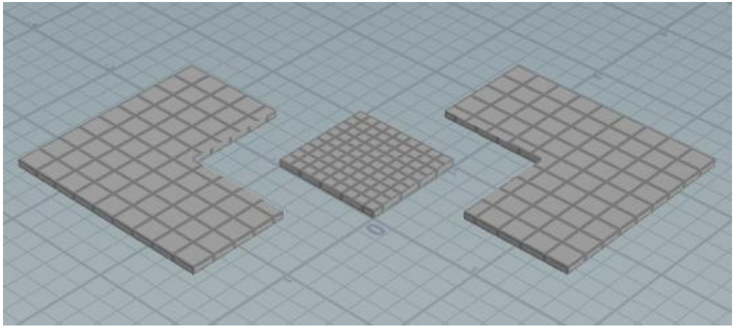


Figure 10. Shattering of union, A∪B, into three mutually exclusive parts: A-B, B-A, and A∩B

Grid Animation

With Grid node, polyextrude node generates custom windows to create animation effect. Two copies of grid node are created. Background grid is colored red and front grid is polyextrude with inset attribute set to give the impression of open windows or holes in the grid. Back grid color oscillates between red and blue ($F%2) with animation effect.We get custom animation using simple Grid node. Two grids coupled with polyextrude 'inset' create the color flickering animation effect, see Fig 11. It is a simple animation with colors alternating between red and green giving the animation effect. Such animation can be accomplished with other nodes also, e.g. torus on top of the spherical surface.

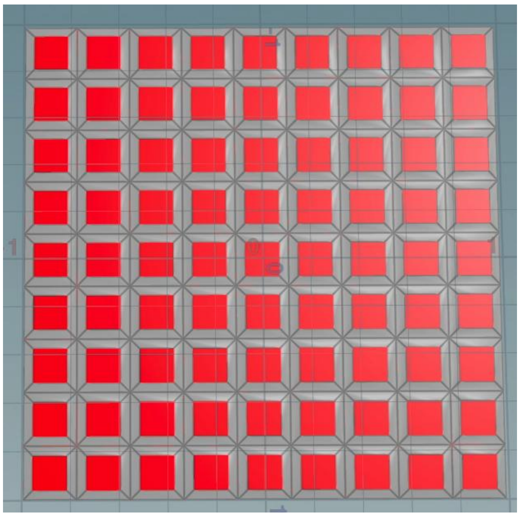


Figure 11. Two grids and polyextrude 'inset' create the color flickering animation effect.

Grid Table: 3x3 Grid node is used to create a rectangular table top. Polyextrude is used to create tabletop and a leg from grid nodes. Copy To Points node may also be used to assemble the table:by creating one leg and copying it to table top at selected group of table vertices completes the table, see Fig 12.The grid node can also be used to create other fancy tables. This process can also be generalized to other nodes as well. In addition to grid node, tableis also created by constructing a leg from circle node and tube node, see Fig 13. This leg is then attached to table top via copy To Points node to make table legs.

Thus, rectangular tabletop and legs can be created from a grid node. Leg is copied on to selected positions on the tabletop. Similarly, circular tabletop and leg is made with circle node, the resulting leg is copied to tabletop to make it circular table.

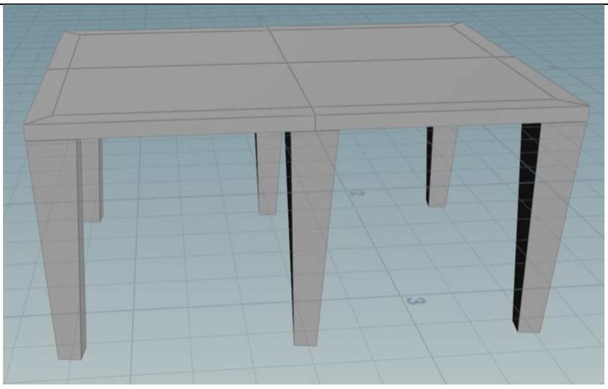


Figure 12. Rectangular table with grid node

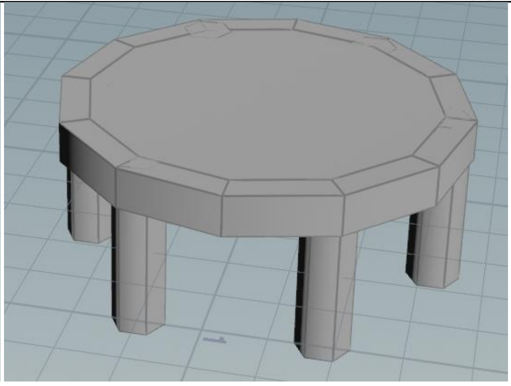


Figure 13. Circular table circle node.

Grid and House Construction

These two housesare created entirely from one grid node and associated operation. First grid is created. Then 1. polyextrude is used to create a pattern with inset on individual primitive of polygonal grid, 2. polyextrude is used to create doors from grid, 3. polyextrude is used on grid to create a house building, another polyextrude creates the roof, see Fig 14. In the second Fig 15, house door is created differently from grid and is colored[5].

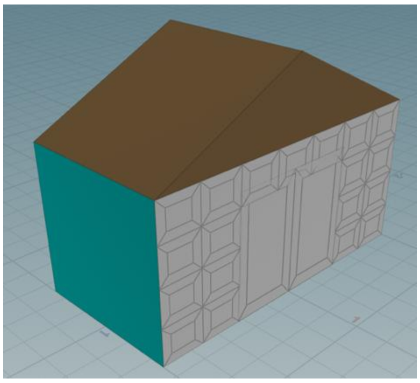


Figure 14 House with custom doors

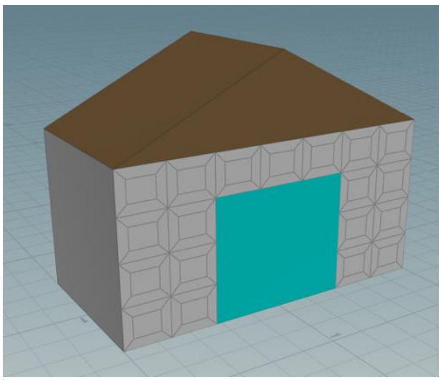


Figure 15 house pattern blocked on the side

Grid node and Playground

Grid is a multipurpose node. Grid is used to create simple playground from rows×columns grid, grid corners are like light posts at night, walls form an enclosure for security, and fractalson top of walls are for cosmetics only. The grid indexes are labelled and one dimensional array than ordered pair. The indexes start at 0. Thus, all points in the r×c grid are labeled from 0 to r×c -1. Since two lines enclose one rectangle, the rectangular primitives in the grid are from 0 to (r-1)×(c-1)-1. The indexes of the four corner primitives become: 0 (c-2) (r-2)(c-1) (r-1)(c-1)-1. Similarly indexes for the four walls become: top wall1 from 0 to (c-2) incremented by 1; left wall2 from 0 to (r-2)(c-1) incremented by c-1; bottom wall3 from (r-2)(c-1) to (r-1)(c-1)-1 incremented by 1; and right wall4 from(c-2) to (r-1)(c-1)-1 incremented by c-1. Similarly, the support pillars in the middle of walls can also be indexed as: (c-2)/2; (r-2)(c-1)/2, (r-1)(c-1)-c/2; r(c-1)/2 -1.

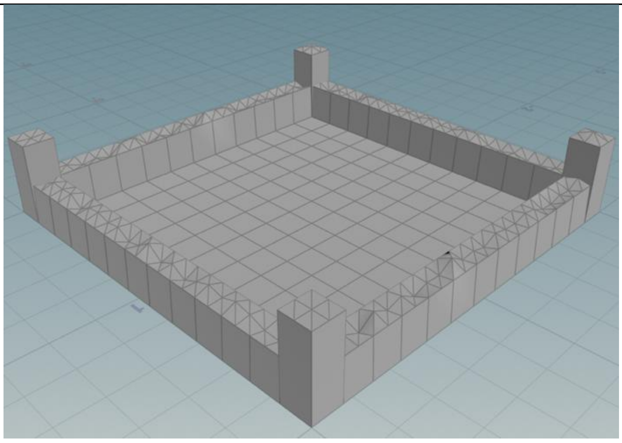


Figure 16. r×c grid with walls and corners

Grid and Grass

Grass blades are created from line node and curve nodemixture to look like natural grass blades. Green color adds greenery to grass. Further to simulate windeffect, transform node, sweep node and bend nodes in conjunction with special function on $Ftogether yield windeffect. Once one set of initial grass blades is created, it is copied on the grid with copyToPointsnode[6], [7].

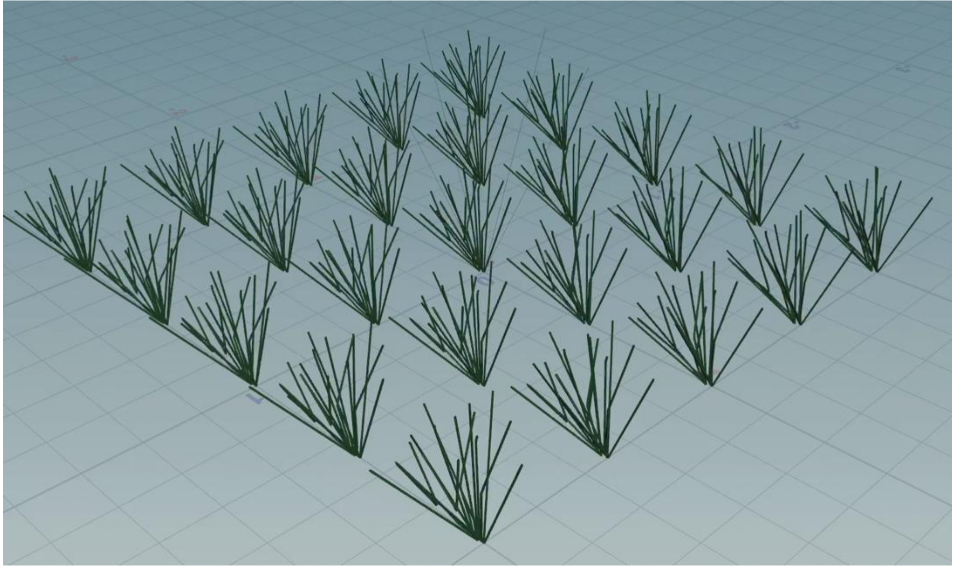


Figure 17. Grid populated with grass blades

Conclusion and Future work

In this paper we have shown how virtual reality Houdini SideFX node based procedural modeling can be used to generate various interesting shapes and patterns using only grid data node.In the coming paper we will show that same grid can be used to create special effects of rain, hailstorm, smoke, fire, earthquake, natural disaster hazards, and hurricane special effects.

We hope that reader will find it interesting, entertaining and get incentive to tacklechallenging models for education and entertainment.

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