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AUCTIONS AND MECHANISM DESIGN

Sushmita Gupta

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Five rounds of auction saw telcos focus on four spectrum bands



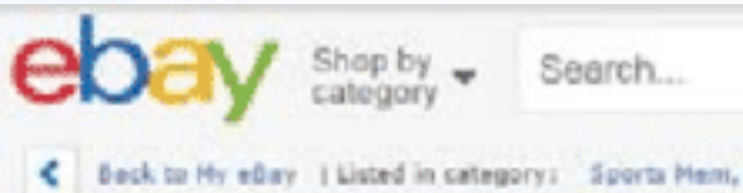
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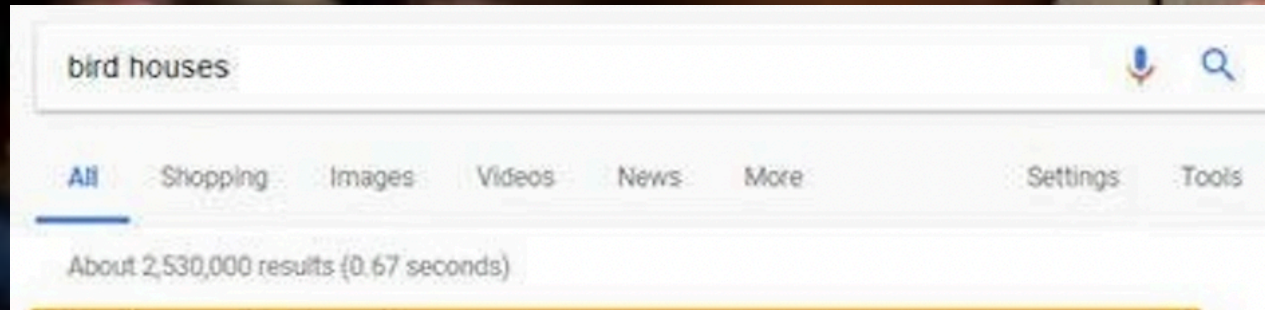
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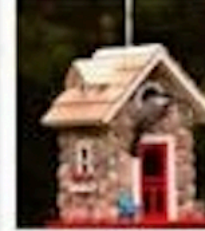
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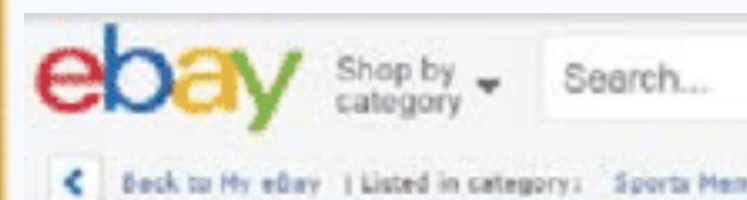
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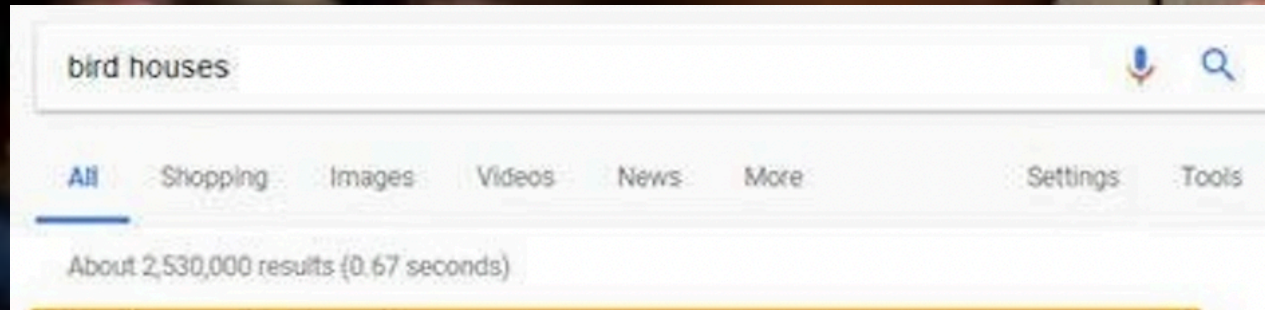
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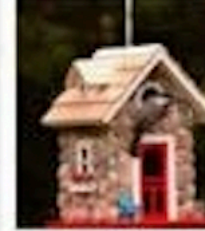
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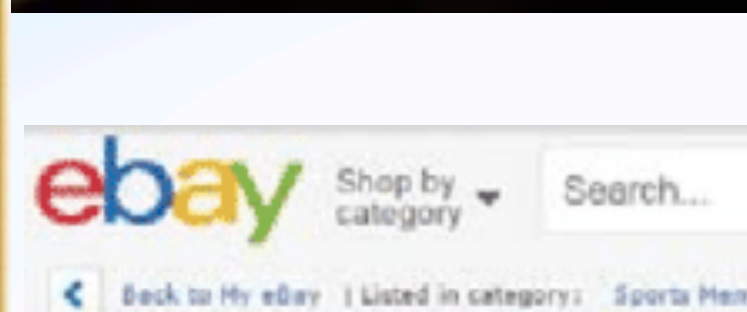
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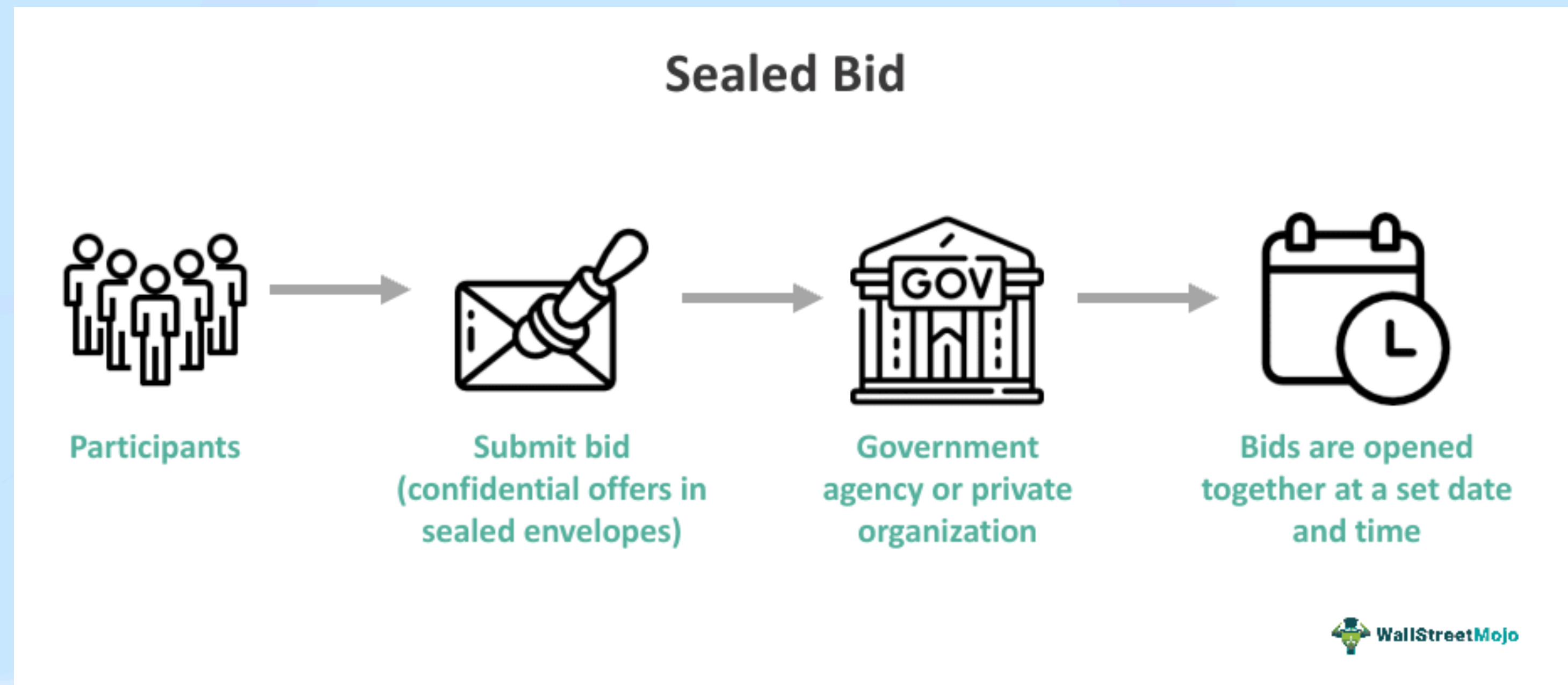
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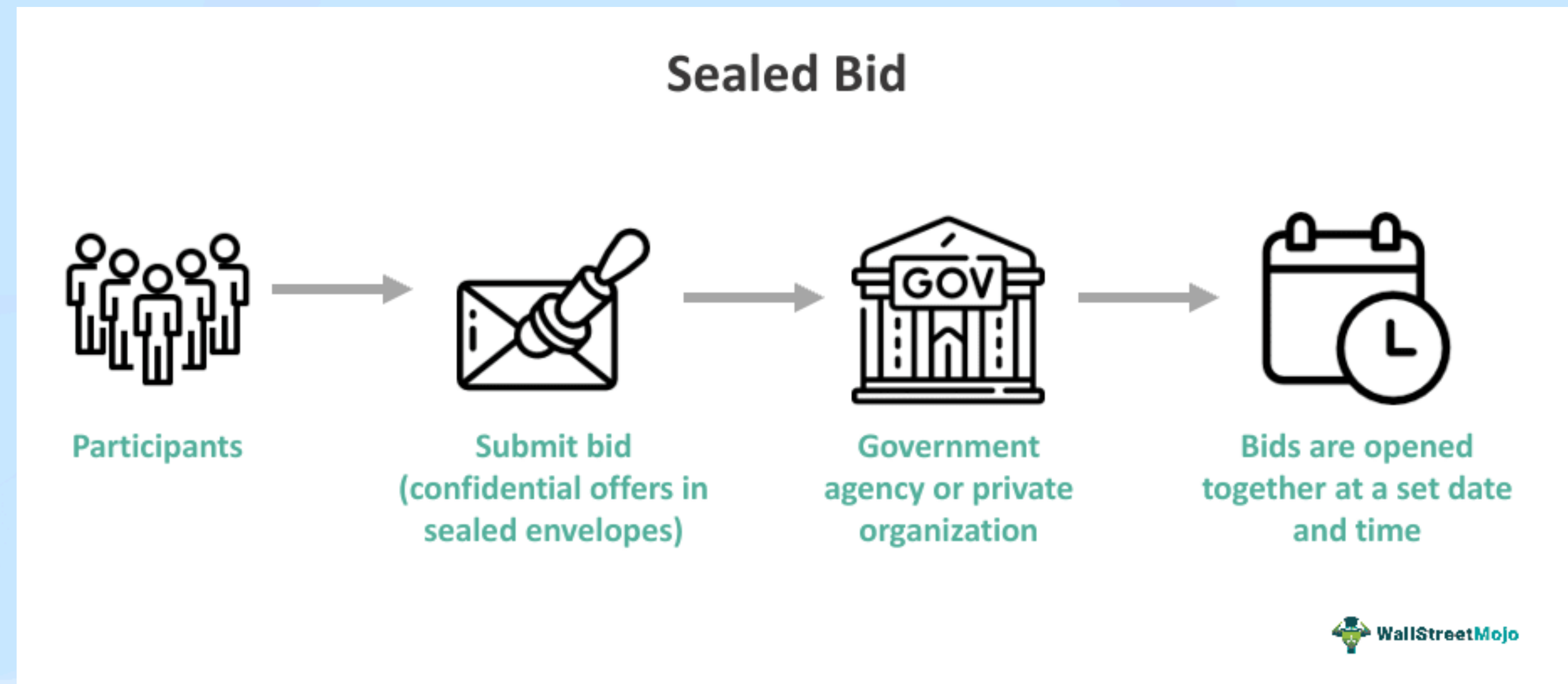
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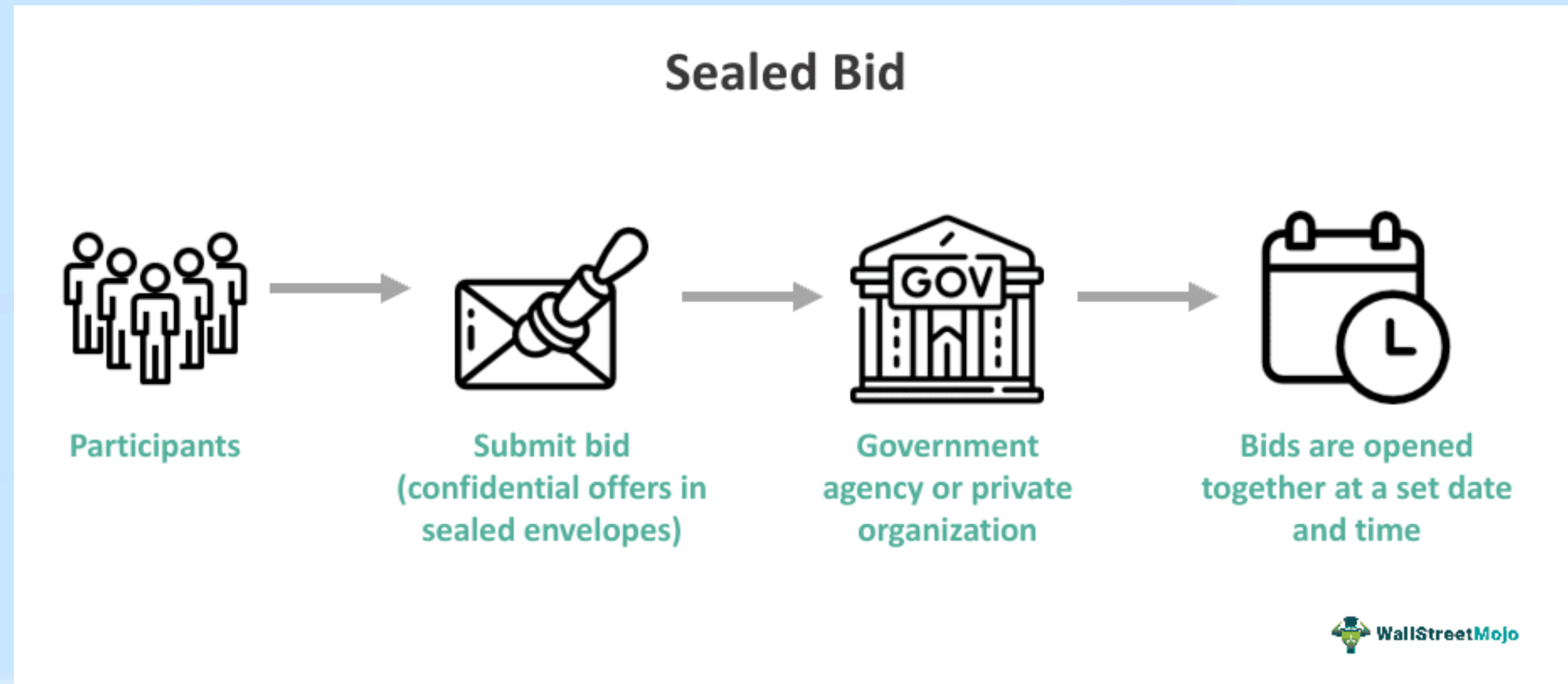


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Some Questions:

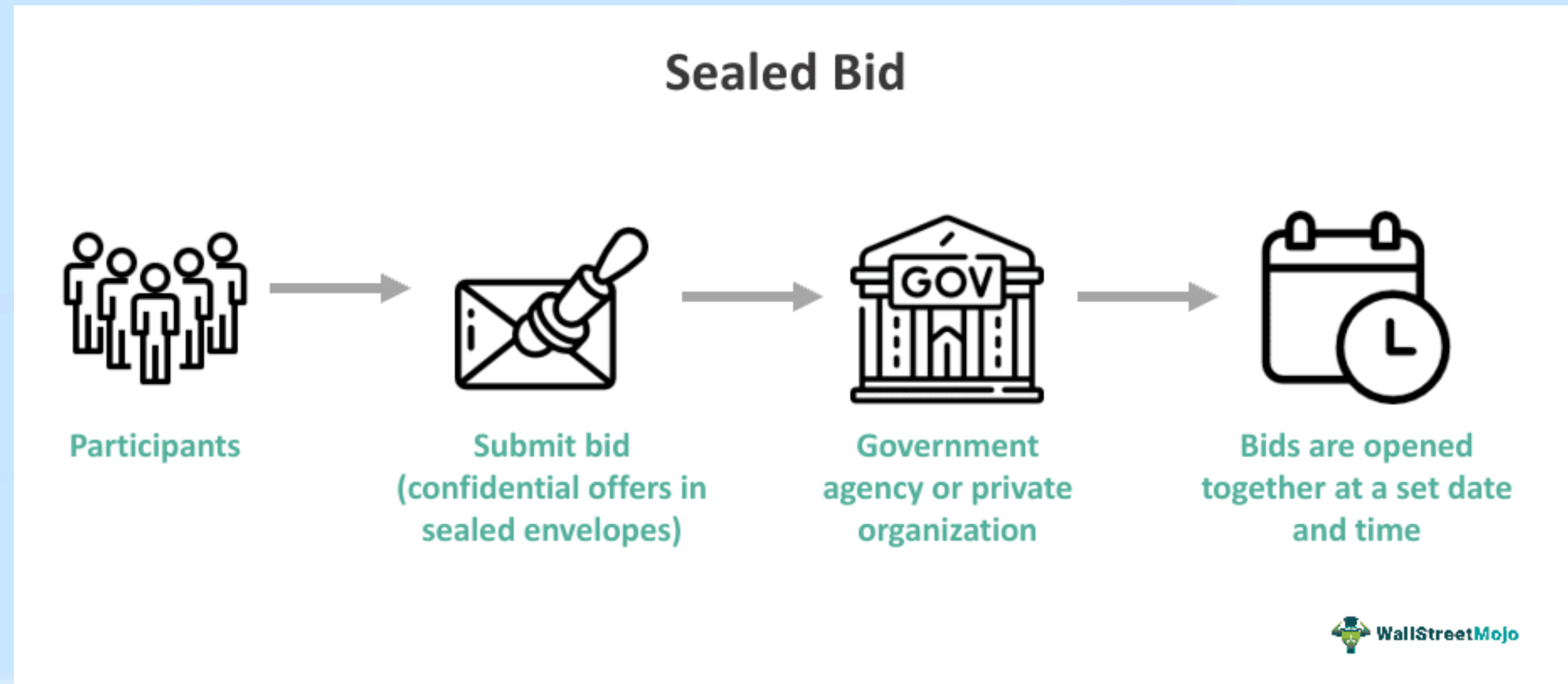
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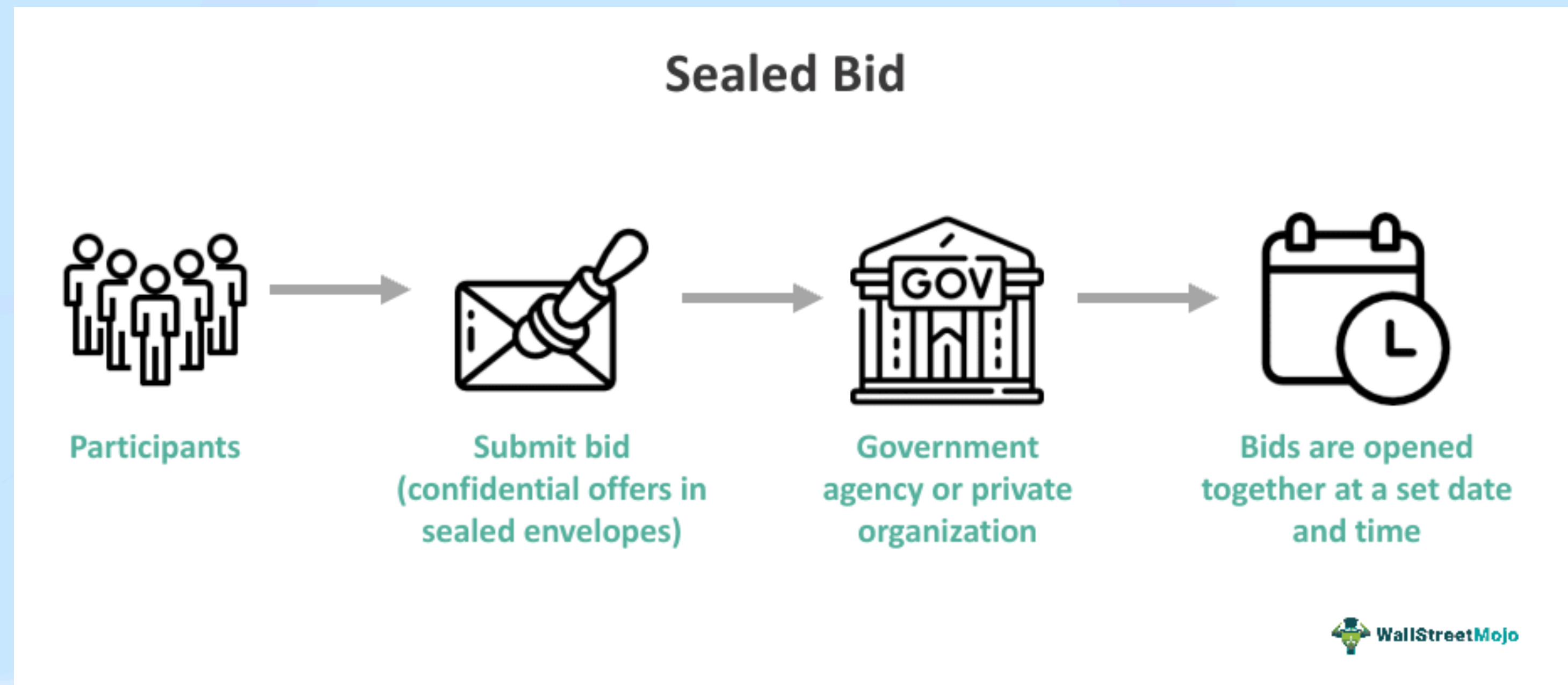


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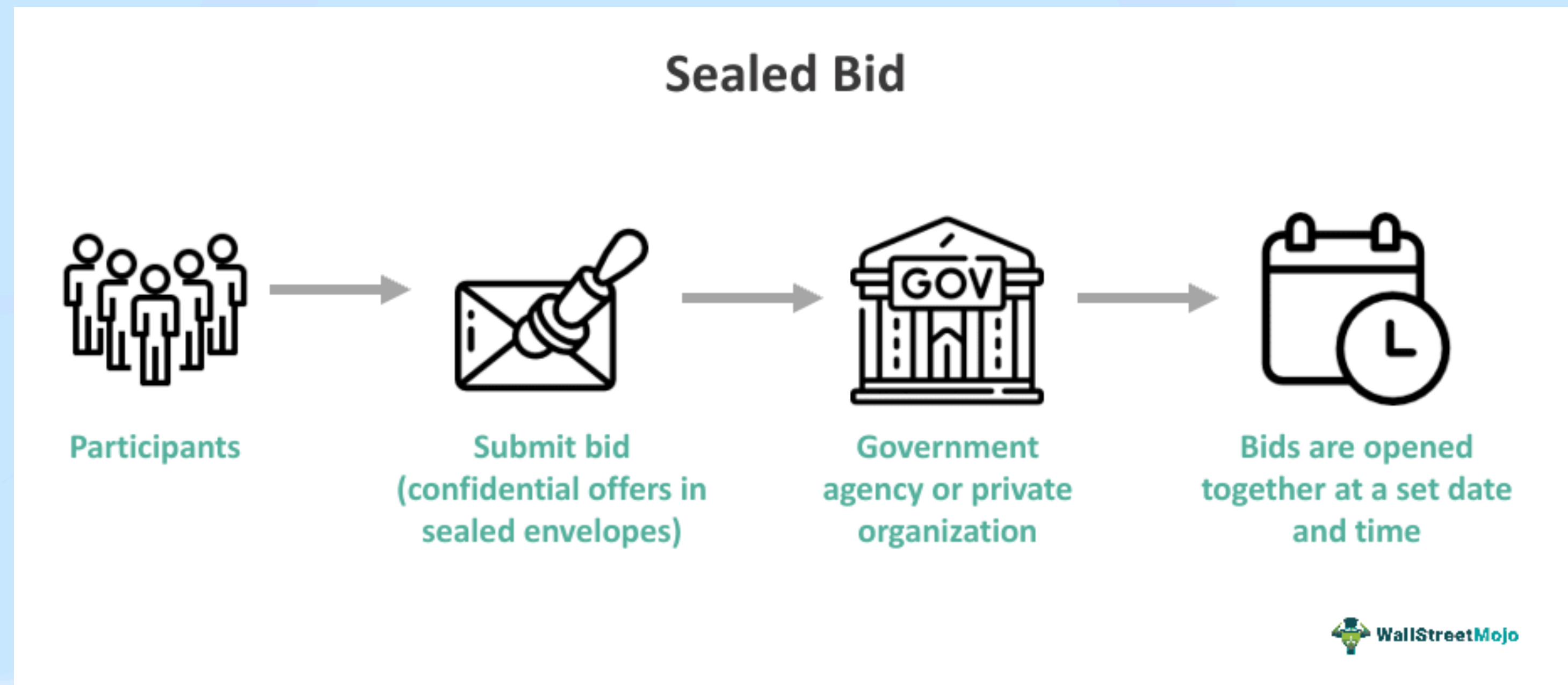
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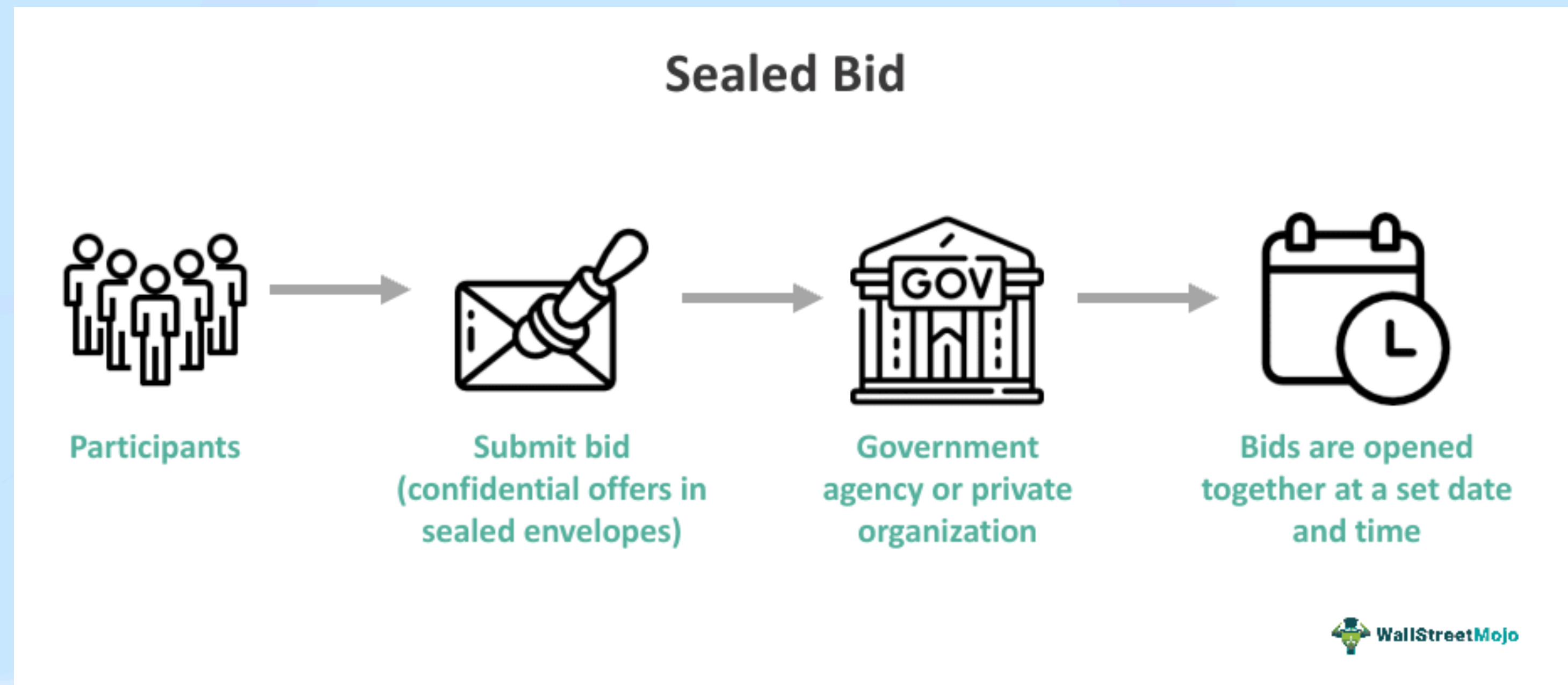
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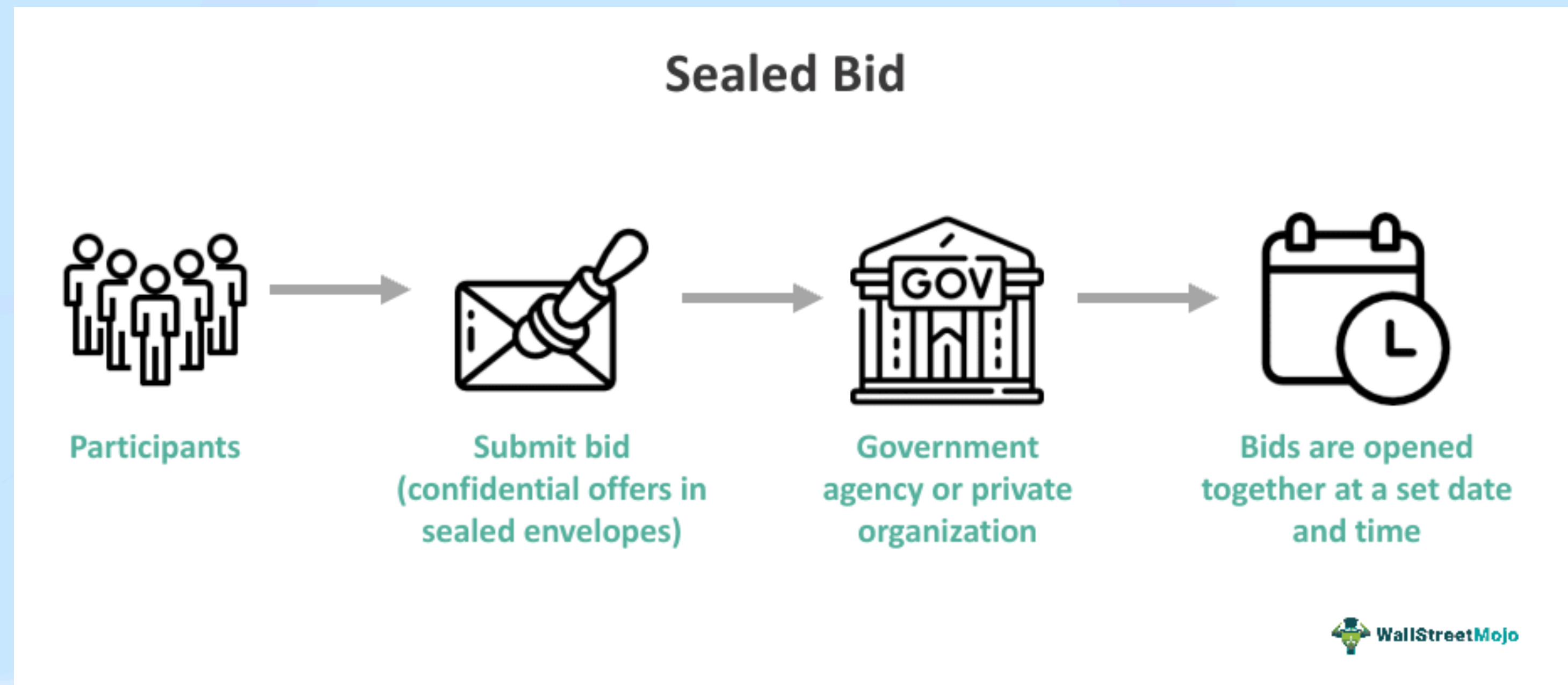
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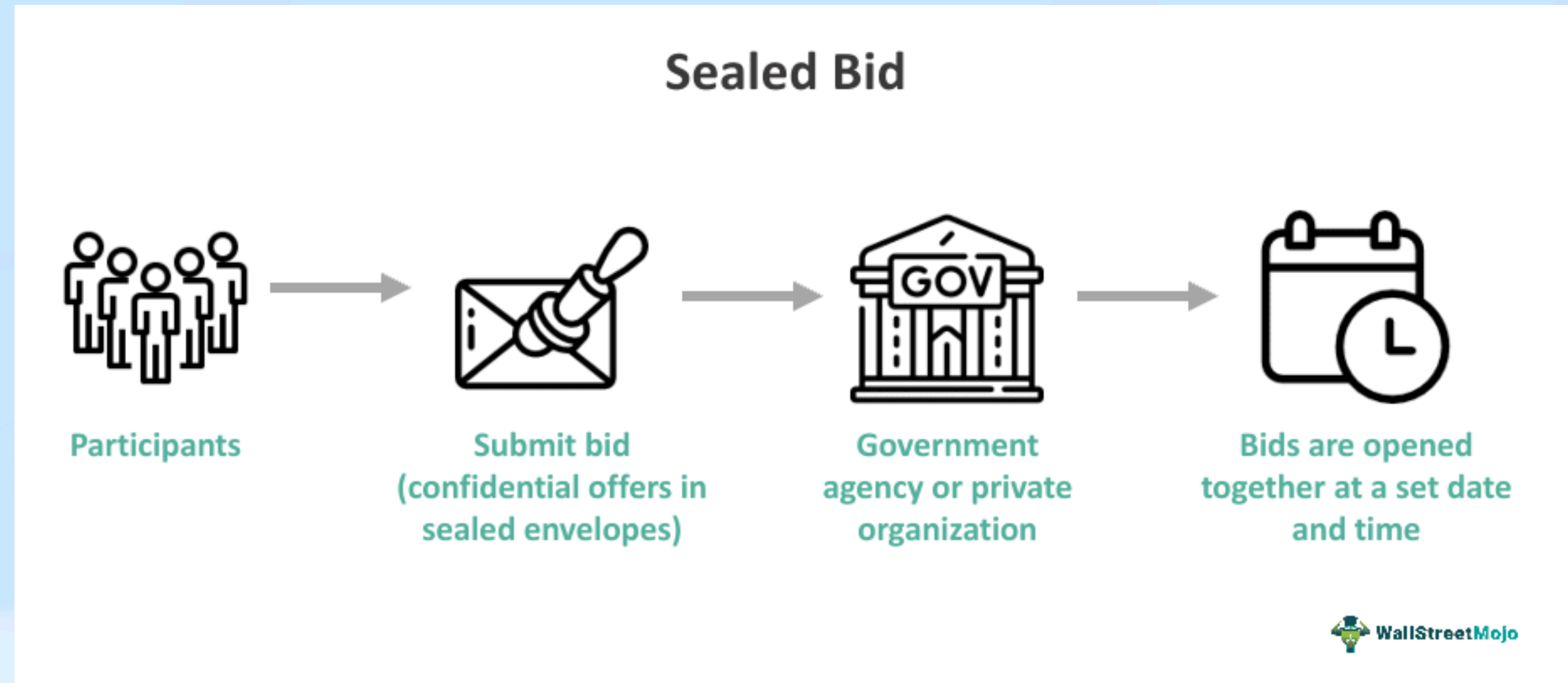
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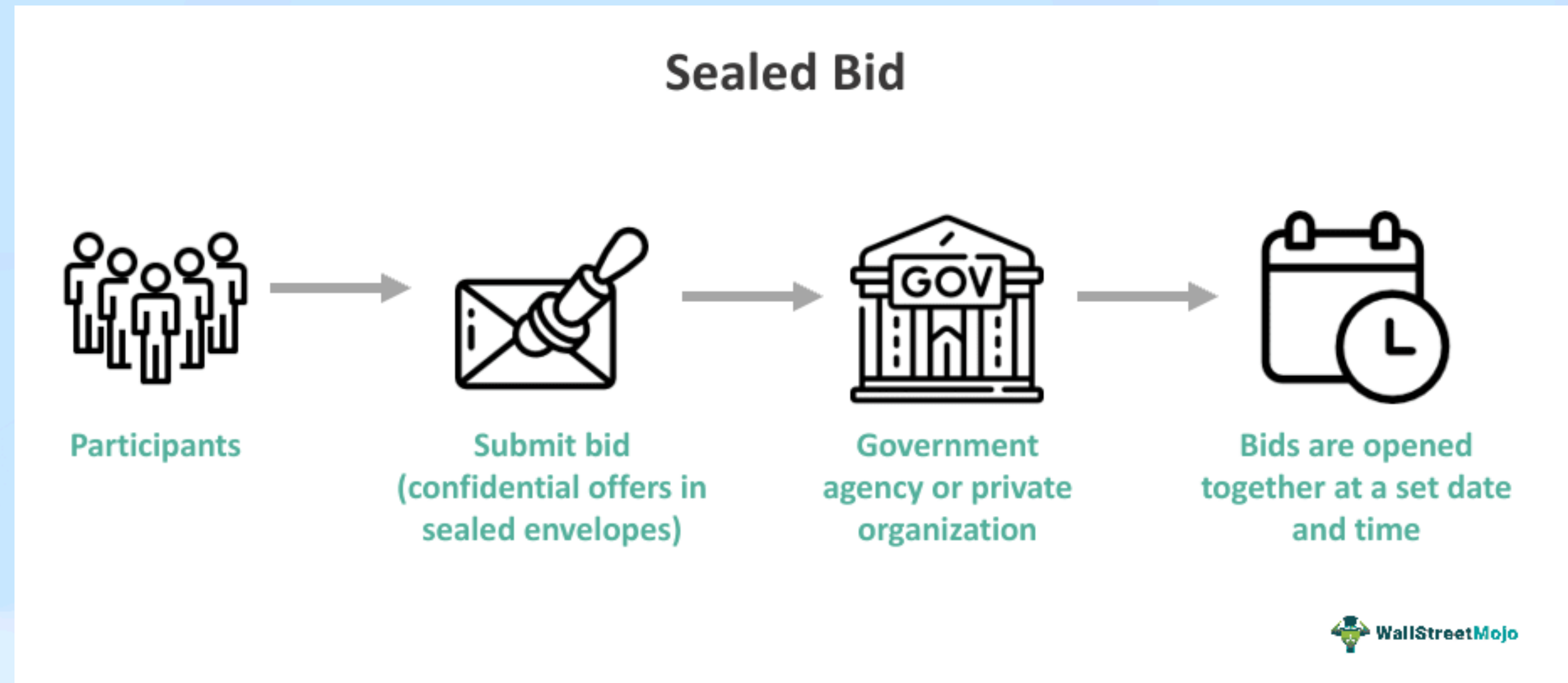
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A slight tweak ... Second price

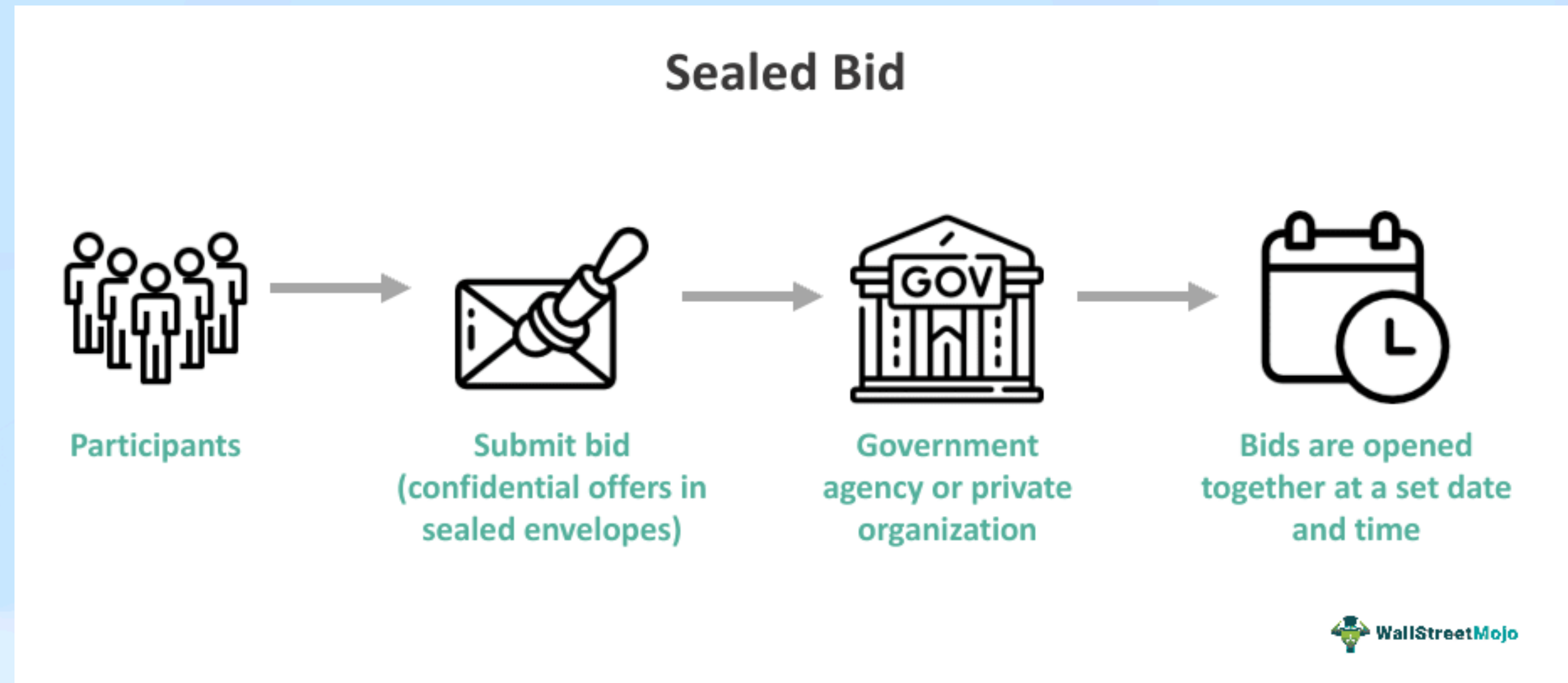


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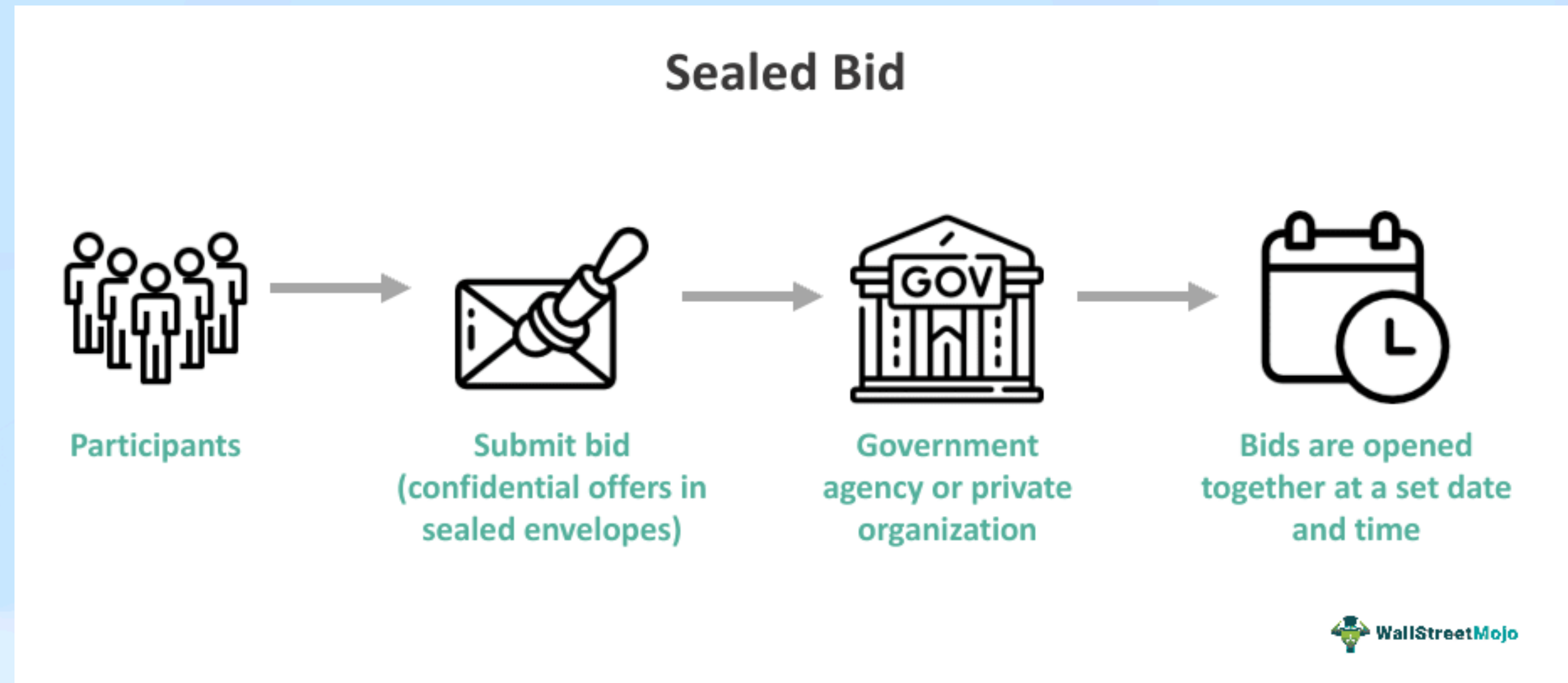
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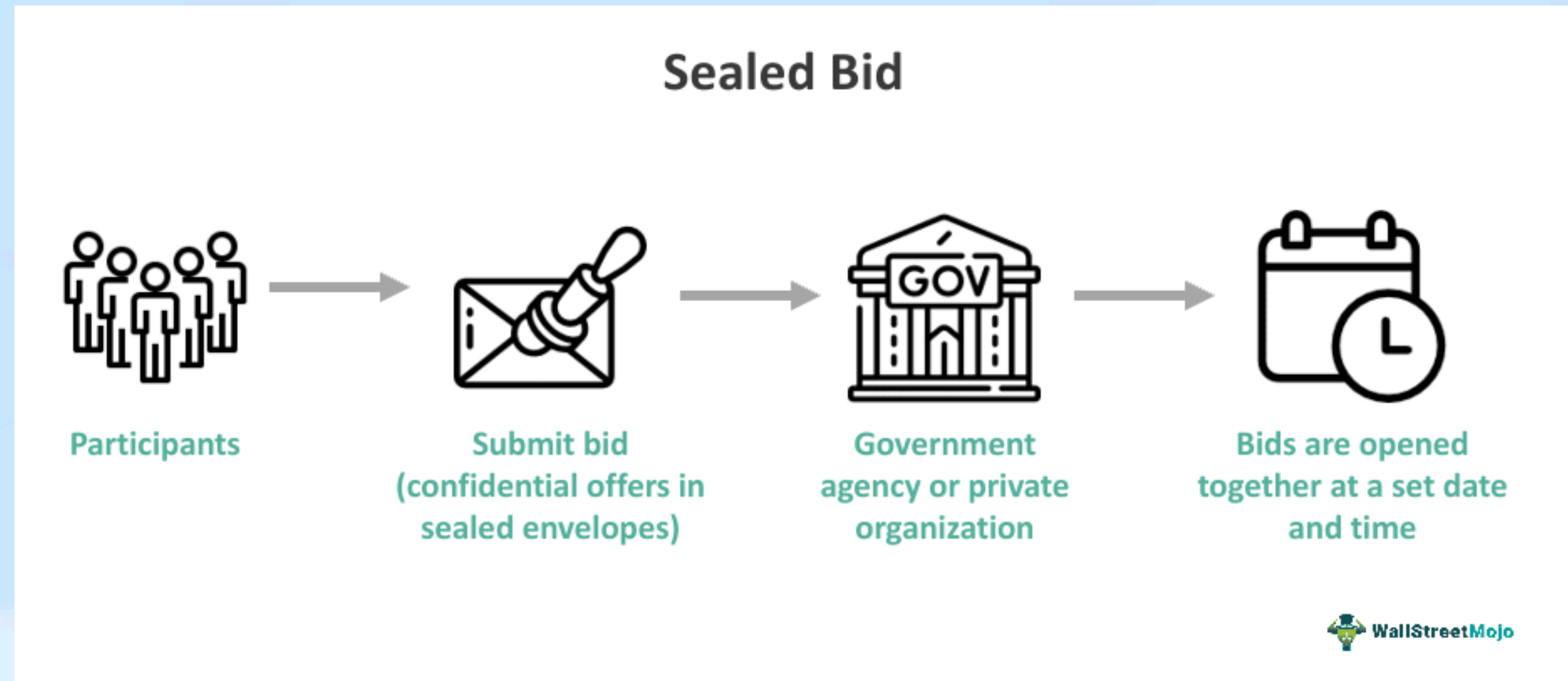


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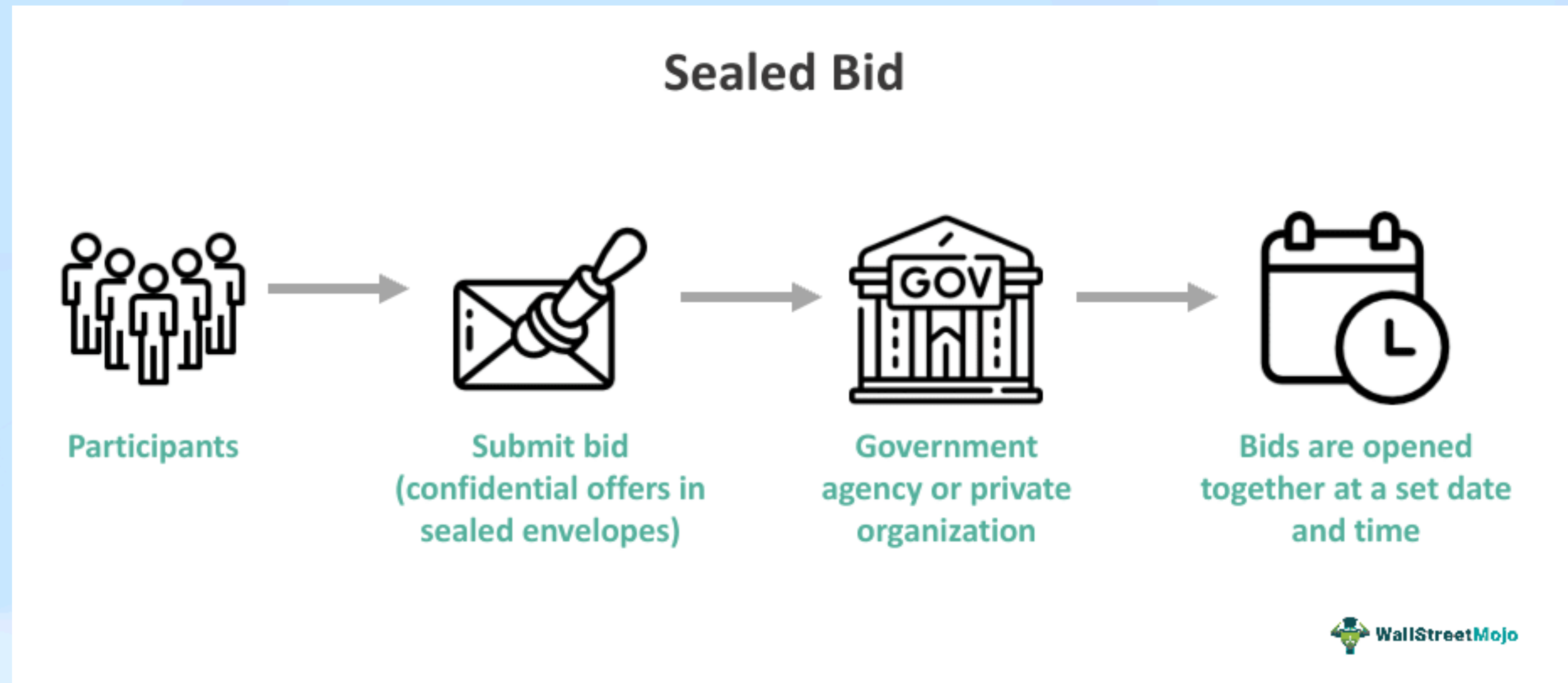
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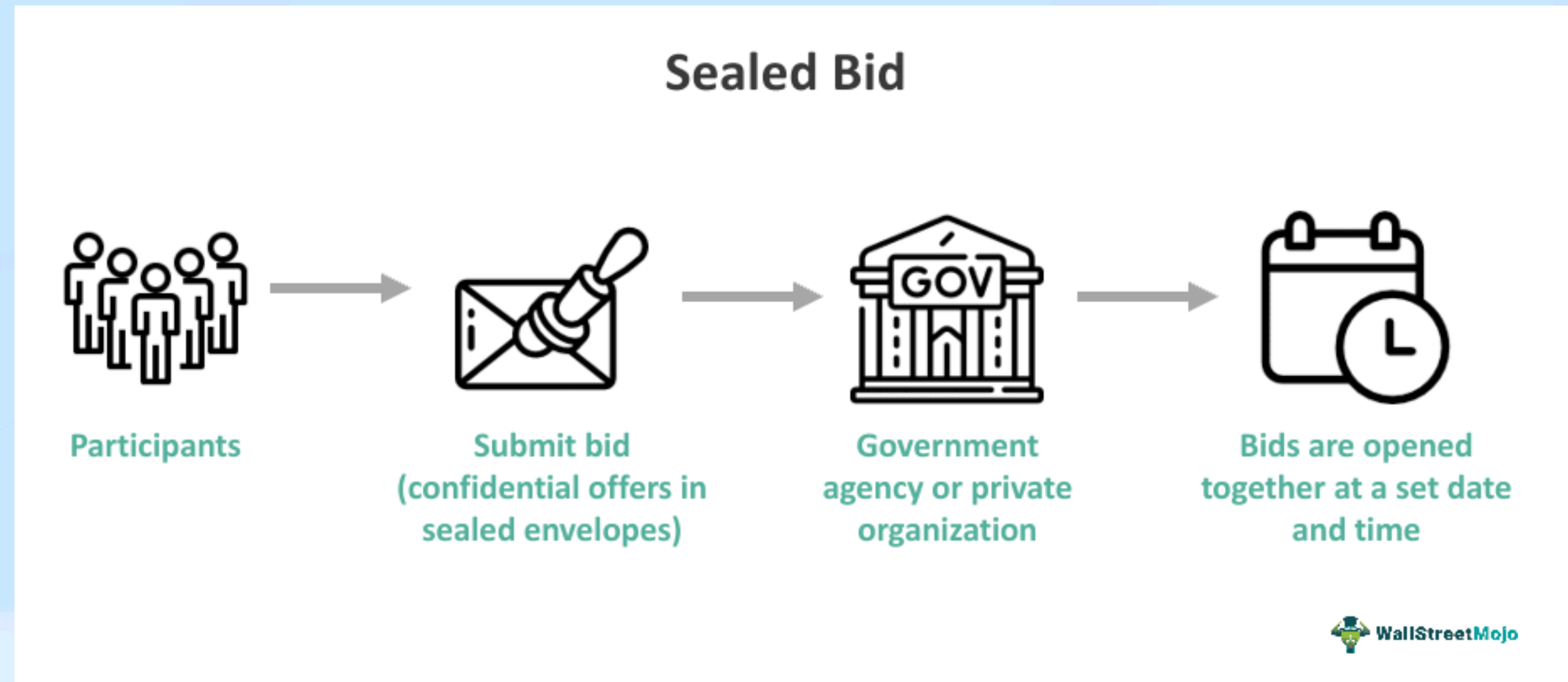
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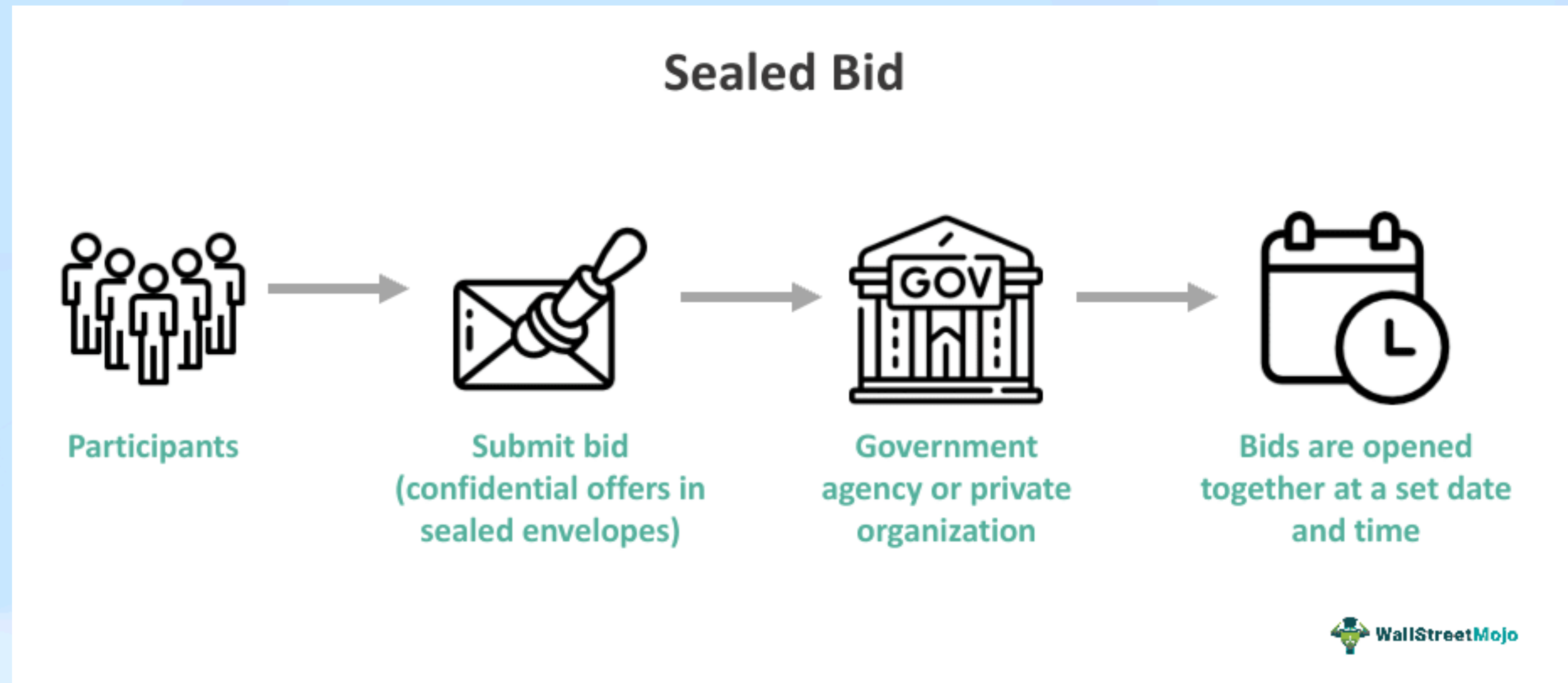
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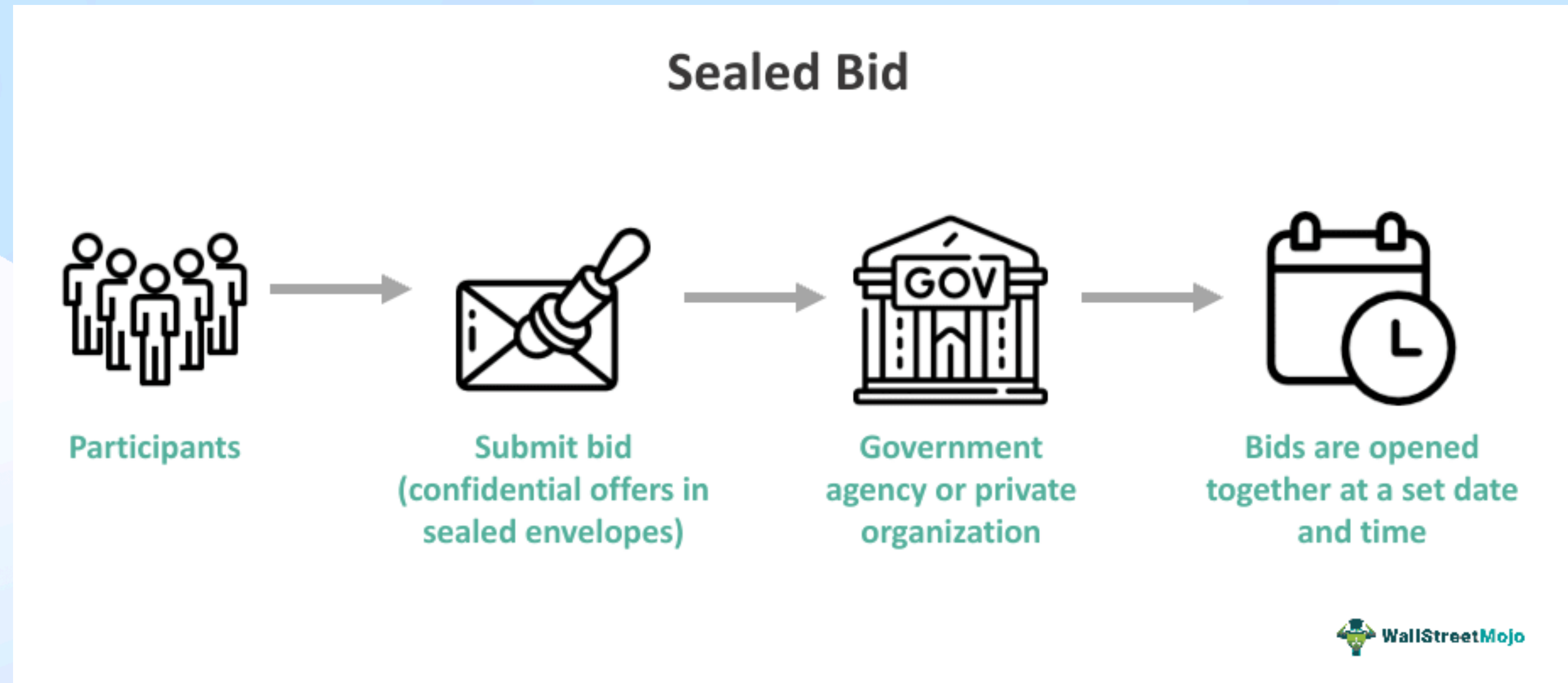
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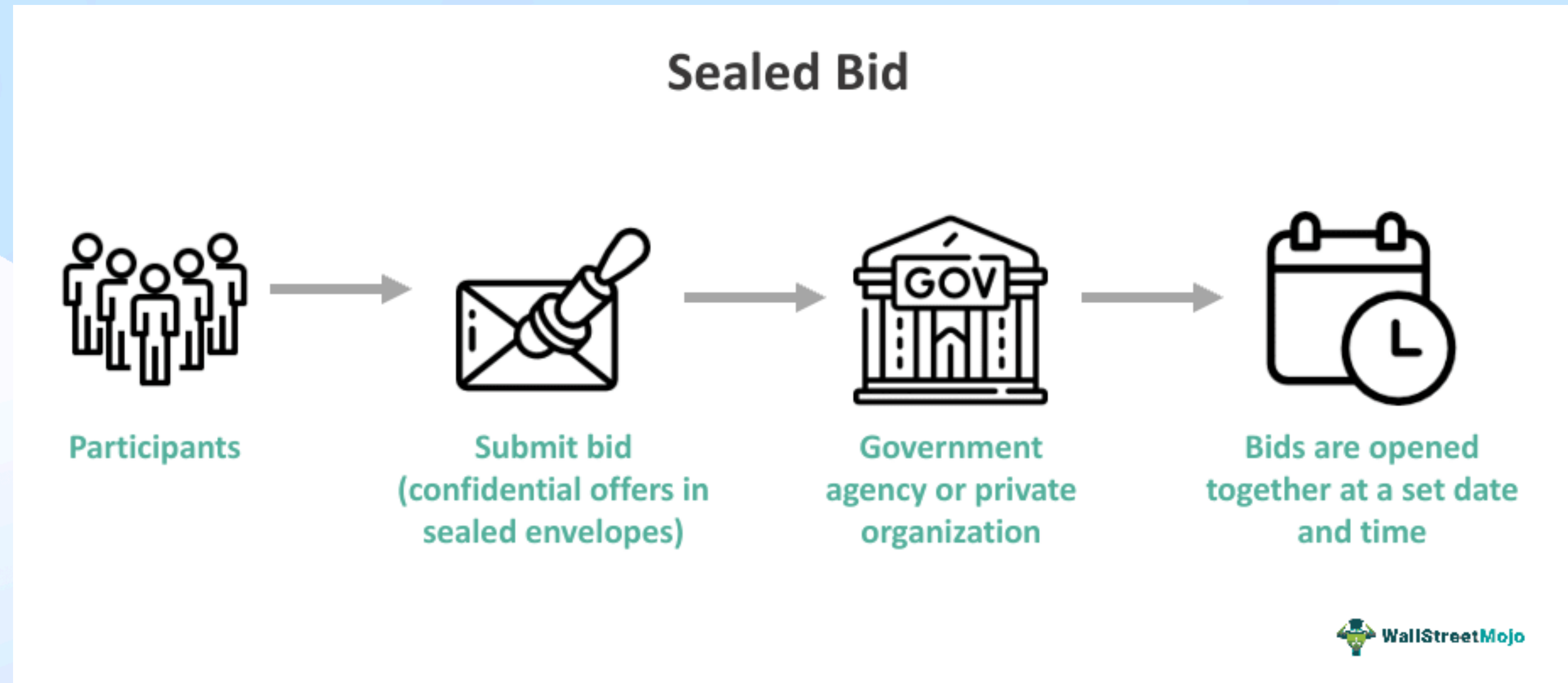
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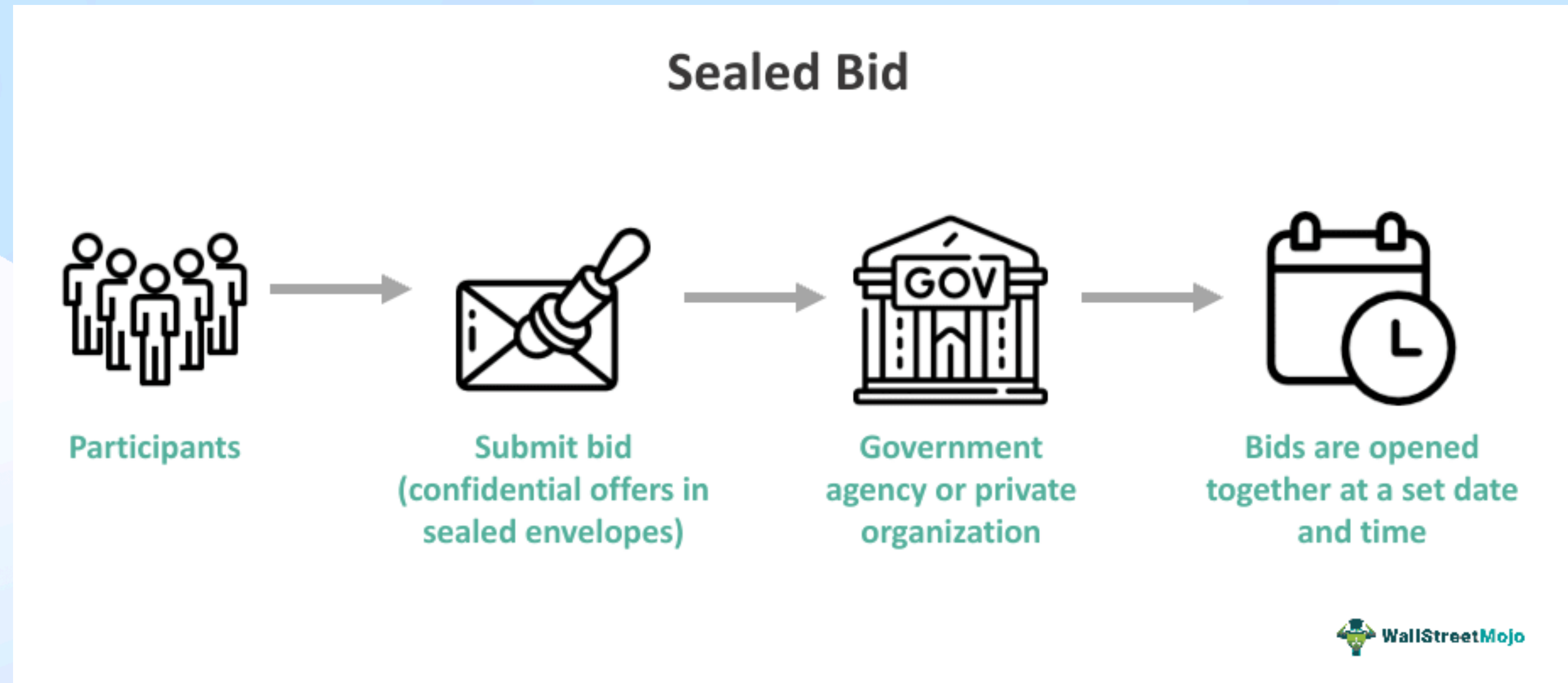


First price vs Second price: What did we gain ?



Truthful participation is guaranteed!

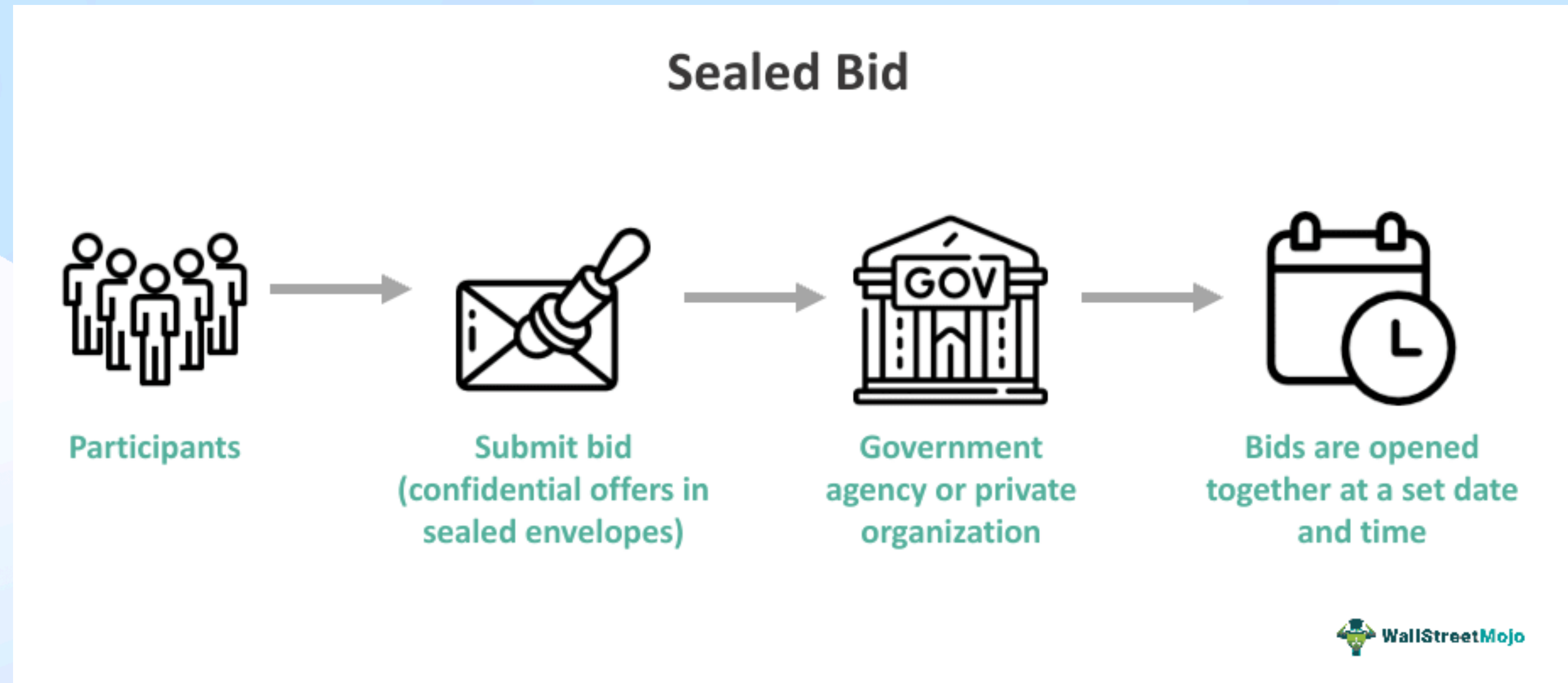
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Named after William Vickery

A more general phenomenon

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Single-parameter setting

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BestNest.com: Bird Houses. Buy a Bird House at BestNest.com!
https://www.bestnest.com/bestnest/bird_houses.asp
Birding has become increasingly popular over the years, and expanding your bird garden to offer cozy housing is another way to enjoy your feathered friends. Placing a bird house in your yard provides needed shelter during the colder months. The different types and sizes of houses accommodate varied bird species, so it...
Decorative Bird Houses - Bluebird Houses - Duck Houses - Purple Martin Houses

Best 25+ Birdhouses ideas on Pinterest | Birdhouse, Building bird ...
<https://www.pinterest.com/explore/birdhouses/>
Find and save ideas about Birdhouses on Pinterest. | See more ideas about Birdhouse, Building bird houses and Diy birdhouse.

Birdhouses | Amazon.com
<https://www.amazon.com/Birdhouses/b?ie=UTF8&node=553634>
Results 1 - 24 of 5250 - Online shopping for Birdhouses - Birds from a great selection at Patio, Lawn & Garden Store.

Shop for bird houses on Google Sponsored

 Gingerbread-Style Birdhouse... \$19.96 Houzz Free shipping	 Gone Fishin Birdhouse... \$15.16 Houzz Free shipping	 Stone Cottage Birdhouse \$39.95 Plow & Hearth Special offer
 Loli Designs Outdoor Pitch... \$95.00 Lumens.com Free shipping	 Wreath Cottage Birdhouse \$59.95 Plow & Hearth Special offer	 White Chalet Hanging Bird... \$39.99 Yard Envy ★★★★★ (7)
 Rustic Cabin Birdhouse, Blue... \$59.00 Houzz Free shipping	 Heath Outdoor Products AH-24... \$96.00 Amazon.com Free shipping	 Heartwood Nottingham... \$67.08 Google Express Free shipping

→ More on Google

An industry altering marketplace

SPONSORED SEARCH AUCTION

1. Keywords are auctioned

bird houses

All Shopping Images Videos News More Settings Tools

About 2,530,000 results (0.67 seconds)

Birdhouses | Houzz - houzz.com
 www.houzz.com/Outdoor-Decorations
4.6 ★★★★★ rating for houzz.com
Houzz® - Find The Perfect Products For Your Home. Shop Online Today!
Curated Collections - Competitive Prices - Save Up To 50% - Unique Designs - Top Brands & Styles
Houzz is a game changer for all varieties of household items. - Forbes

Outdoor Decor Outdoor Lighting
Outdoor Furnitures Backyard Play

Bird House at Amazon® - Amazon Official Site - amazon.com
 www.amazon.com/
4.7 ★★★★★ rating for amazon.com
Buy Bird House at Amazon. Free Shipping on Qualified Orders.
Shop Best Sellers & Deals - Save with Our Low Prices - Shop Our Huge Selection - Fast Shipping

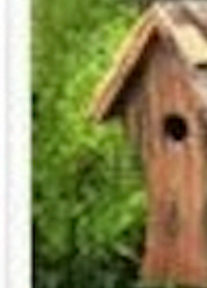
Huge Bird House Sale - Free Shipping, Great Selection - yardenvy.com
 www.yardenvy.com/Bird_Houses
Choose from a wide variety of designer bird houses plus get free shipping today!
Types: Victorian Bird Houses, Decorative Bird Houses, Purple Martin Bird Houses...
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→ More on Google

An industry altering marketplace

SPONSORED SEARCH AUCTION

1. Keywords are auctioned

2. k slots available

The screenshot displays a Google search for "bird houses". The search bar at the top shows the query and a microphone icon. Below the search bar, navigation tabs for "All", "Shopping", "Images", "Videos", "News", "More", "Settings", and "Tools" are visible. The results section indicates "About 2,530,000 results (0.67 seconds)".

The main results area features several organic search results, including:

- Birdhouses | Houzz - houzz.com**: A sponsored result with a 4.6-star rating, advertising curated collections and competitive prices for outdoor decor and lighting.
- Bird House at Amazon® - Amazon Official Site - amazon.com**: A sponsored result with a 4.7-star rating, offering free shipping on qualified orders.
- Huge Bird House Sale - Free Shipping, Great Selection - yardenvy.com**: A sponsored result advertising a wide variety of designer bird houses.
- BestNest.com: Bird Houses. Buy a Bird House at BestNest.com!**: A result with a detailed description of bird houses and their benefits.
- Best 25+ Birdhouses ideas on Pinterest | Birdhouse, Building bird ...**: A result linking to Pinterest for birdhouse ideas.
- Birdhouses | Amazon.com**: A result linking to Amazon for birdhouses.

On the right side, there is a "Shop for bird houses on Google" section, which is a sponsored shopping carousel. It displays a grid of bird house products with images, titles, prices, and shipping information:

- Gingerbread-Style Birdhouse**: \$19.96, Houzz, Free shipping.
- Gone Fishin' Birdhouse**: \$15.16, Houzz, Free shipping.
- Stone Cottage Birdhouse**: \$39.95, Plow & Hearth, Special offer.
- Loli Designs Outdoor Pitch**: \$95.00, Lumens.com, Free shipping.
- Wreath Cottage Birdhouse**: \$59.95, Plow & Hearth, Special offer.
- White Chalet Hanging Bird**: \$39.99, Yard Envy, 5 stars (7).
- Rustic Cabin Birdhouse, Blue**: \$59.00, Houzz, Free shipping.
- Heath Outdoor Products AH-24**: \$96.00, Amazon.com, Free shipping.
- Heartwood Nottingham**: \$67.08, Google Express, Free shipping.

At the bottom of the shopping carousel, there is a link to "More on Google".

An industry altering marketplace

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2. k slots available

Higher slots are more valuable

CTRS: $\alpha_1 > \alpha_2 > \dots > \alpha_k$

The screenshot shows a Google search for "bird houses". The search bar at the top contains the text "bird houses" and a magnifying glass icon. Below the search bar, there are tabs for "All", "Shopping", "Images", "Videos", "News", "More", "Settings", and "Tools". The search results indicate "About 2,530,000 results (0.67 seconds)".

The main search results are listed below the tabs. The first result is "Birdhouses | Houzz - houzz.com" with a link to "www.houzz.com/Outdoor-Decorations". It has a 4.6 star rating and a description: "Houzz® - Find The Perfect Products For Your Home. Shop Online Today! Curated Collections - Competitive Prices - Save Up To 50% - Unique Designs - Top Brands & Styles. Houzz is a game changer for all varieties of household items. - Forbes". Below the description are links for "Outdoor Decor", "Outdoor Furnitures", "Outdoor Lighting", and "Backyard Play".

The second result is "Bird House at Amazon® - Amazon Official Site - amazon.com" with a link to "www.amazon.com/". It has a 4.7 star rating and a description: "Buy Bird House at Amazon. Free Shipping on Qualified Orders. Shop Best Sellers & Deals - Save with Our Low Prices - Shop Our Huge Selection - Fast Shipping".

The third result is "Huge Bird House Sale - Free Shipping, Great Selection - yardenvy.com" with a link to "www.yardenvy.com/Bird_Houses". It has a description: "Choose from a wide variety of designer bird houses plus get free shipping today! Types: Victorian Bird Houses, Decorative Bird Houses, Purple Martin Bird Houses... Patio Lights - Bird Feeders - Holiday Lights - String Lights - Outdoor Living".

Below these results is a section titled "BestNest.com: Bird Houses. Buy a Bird House at BestNest.com!" with a link to "https://www.bestnest.com/bestnest/bird_houses.asp". It has a description: "Birding has become increasingly popular over the years, and expanding your bird garden to offer cozy housing is another way to enjoy your feathered friends. Placing a bird house in your yard provides needed shelter during the colder months. The different types and sizes of houses accommodate varied bird species, so it... Decorative Bird Houses - Bluebird Houses - Duck Houses - Purple Martin Houses".

Below this is a section titled "Best 25+ Birdhouses ideas on Pinterest | Birdhouse, Building bird ..." with a link to "https://www.pinterest.com/explore/birdhouses/". It has a description: "Find and save ideas about Birdhouses on Pinterest. | See more ideas about Birdhouse, Building bird houses and Diy birdhouse".

The final result is "Birdhouses | Amazon.com" with a link to "https://www.amazon.com/Birdhouses/b?ie=UTF8&node=553634". It has a description: "Results 1 - 24 of 5250 - Online shopping for Birdhouses - Birds from a great selection at Patio, Lawn & Garden Store".

On the right side of the search results, there is a section titled "Shop for bird houses on Google" with a "Sponsored" label. It contains a grid of nine birdhouse products, each with an image, a title, a price, and a link to the seller. The products are:

- Gingerbread-Style Birdhouse, \$19.96, Houzz, Free shipping
- Gone Fishin Birdhouse, \$15.16, Houzz, Free shipping
- Stone Cottage Birdhouse, \$39.95, Plow & Hearth, Special offer
- Loli Designs Outdoor Pitch, \$95.00, Lumens.com, Free shipping
- Wreath Cottage Birdhouse, \$59.95, Plow & Hearth, Special offer
- White Chalet Hanging Bird, \$39.99, Yard Envy, (7) stars
- Rustic Cabin Birdhouse, Blue, \$59.00, Houzz, Free shipping
- Heath Outdoor Products AH-24, \$96.00, Amazon.com, Free shipping
- Heartwood Nottingham, \$67.08, Google Express, Free shipping

At the bottom of the "Shop for bird houses on Google" section, there is a link "More on Google".

An industry altering marketplace

SPONSORED SEARCH AUCTION

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2. k slots available

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The screenshot shows a Google search for "bird houses". The search bar at the top contains the text "bird houses" and a magnifying glass icon. Below the search bar, there are tabs for "All", "Shopping", "Images", "Videos", "News", "More", "Settings", and "Tools". The search results indicate "About 2,530,000 results (0.67 seconds)".

The organic search results are as follows:

- Birdhouses | Houzz - houzz.com**
www.houzz.com/Outdoor-Decorations
4.6 ★★★★★ rating for houzz.com
Houzz® - Find The Perfect Products For Your Home. Shop Online Today!
Curated Collections - Competitive Prices - Save Up To 50% - Unique Designs - Top Brands & Styles
Houzz is a game changer for all varieties of household items. - Forbes
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Birding has become increasingly popular over the years, and expanding your bird garden to offer cozy housing is another way to enjoy your feathered friends. Placing a bird house in your yard provides needed shelter during the colder months. The different types and sizes of houses accommodate varied bird species, so it...
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Find and save ideas about Birdhouses on Pinterest. | See more ideas about Birdhouse, Building bird houses and Diy birdhouse.
- Birdhouses | Amazon.com**
https://www.amazon.com/Birdhouses/b?ie=UTF8&node=553634
Results 1 - 24 of 5250 - Online shopping for Birdhouses - Birds from a great selection at Patio, Lawn & Garden Store.

The sponsored search results are titled "Shop for bird houses on Google" and "Sponsored". They are arranged in a grid of 12 items, each with an image, title, price, and shipping information:

- Gingerbread-Style Birdhouse...**
\$19.96
Houzz
Free shipping
- Gone Fishin Birdhouse...**
\$15.16
Houzz
Free shipping
- Stone Cottage Birdhouse**
\$39.95
Piow & Hearth
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- Loli Designs Outdoor Pitch...**
\$95.00
Lumens.com
Free shipping
- Wreath Cottage Birdhouse**
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Piow & Hearth
Special offer
- White Chalet Hanging Bird...**
\$39.99
Yard Envy
★★★★★ (7)
- Rustic Cabin Birdhouse, Blue...**
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Houzz
Free shipping
- Heath Outdoor Products AH-24...**
\$96.00
Amazon.com
Free shipping
- Heartwood Nottingham...**
\$67.08
Google Express
Free shipping

At the bottom right of the sponsored section, there is a link: → More on Google

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2. k slots available

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3. Advertiser has valuation v_i for clicks

4. Expected value derived by advertiser i from slot j is $v_i \alpha_j$

The screenshot shows a Google search for "bird houses". The search bar at the top contains the text "bird houses" and a magnifying glass icon. Below the search bar, there are tabs for "All", "Shopping", "Images", "Videos", "News", "More", "Settings", and "Tools". The search results indicate "About 2,530,000 results (0.67 seconds)".

The first section of results is a large sponsored ad box with a yellow border. It contains three ads:

- Birdhouses | Houzz - houzz.com**
www.houzz.com/Outdoor-Decorations
4.6 ★★★★★ rating for houzz.com
Houzz® - Find The Perfect Products For Your Home. Shop Online Today!
Curated Collections - Competitive Prices - Save Up To 50% - Unique Designs - Top Brands & Styles
Houzz is a game changer for all varieties of household items. - Forbes
Outdoor Decor Outdoor Lighting
Outdoor Furnitures Backyard Play
- Bird House at Amazon® - Amazon Official Site - amazon.com**
www.amazon.com/
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Choose from a wide variety of designer bird houses plus get free shipping today!
Types: Victorian Bird Houses, Decorative Bird Houses, Purple Martin Bird Houses...
Patio Lights - Bird Feeders - Holiday Lights - String Lights - Outdoor Living

Below the sponsored ad box are organic search results:

- BestNest.com: Bird Houses. Buy a Bird House at BestNest.com!**
https://www.bestnest.com/bestnest/bird_houses.asp
Birding has become increasingly popular over the years, and expanding your bird garden to offer cozy housing is another way to enjoy your feathered friends. Placing a bird house in your yard provides needed shelter during the colder months. The different types and sizes of houses accommodate varied bird species, so it...
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Results 1 - 24 of 5250 - Online shopping for Birdhouses - Birds from a great selection at Patio, Lawn & Garden Store.

On the right side of the page, there is a "Shop for bird houses on Google" section with a "Sponsored" label. It displays a grid of nine birdhouse products with their prices and shipping information:

Product	Price	Shipping
Gingerbread-Style Birdhouse,...	\$19.96	Houzz Free shipping
Gone Fishin Birdhouse,...	\$15.16	Houzz Free shipping
Stone Cottage Birdhouse	\$39.95	Piow & Hearth Special offer
Loli Designs Outdoor Pitch...	\$95.00	Lumens.com Free shipping
Wreath Cottage Birdhouse	\$59.95	Piow & Hearth Special offer
White Chalet Hanging Bird...	\$39.99	Yard Envy ★★★★★ (7)
Rustic Cabin Birdhouse, Blue...	\$59.00	Houzz Free shipping
Heath Outdoor Products AH-24...	\$96.00	Amazon.com Free shipping
Heartwood Nottingham...	\$67.08	Google Express Free shipping

At the bottom of the "Shop for bird houses on Google" section, there is a link "More on Google".

Other complex (and complicated) auctions

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First initiated by *Rassenti, Smith, and Bulfin (1982)*, for airport landing slots

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First initiated by *Rassenti, Smith, and Bulfin (1982)*, for airport landing slots

1. Accept bids for bundles of items

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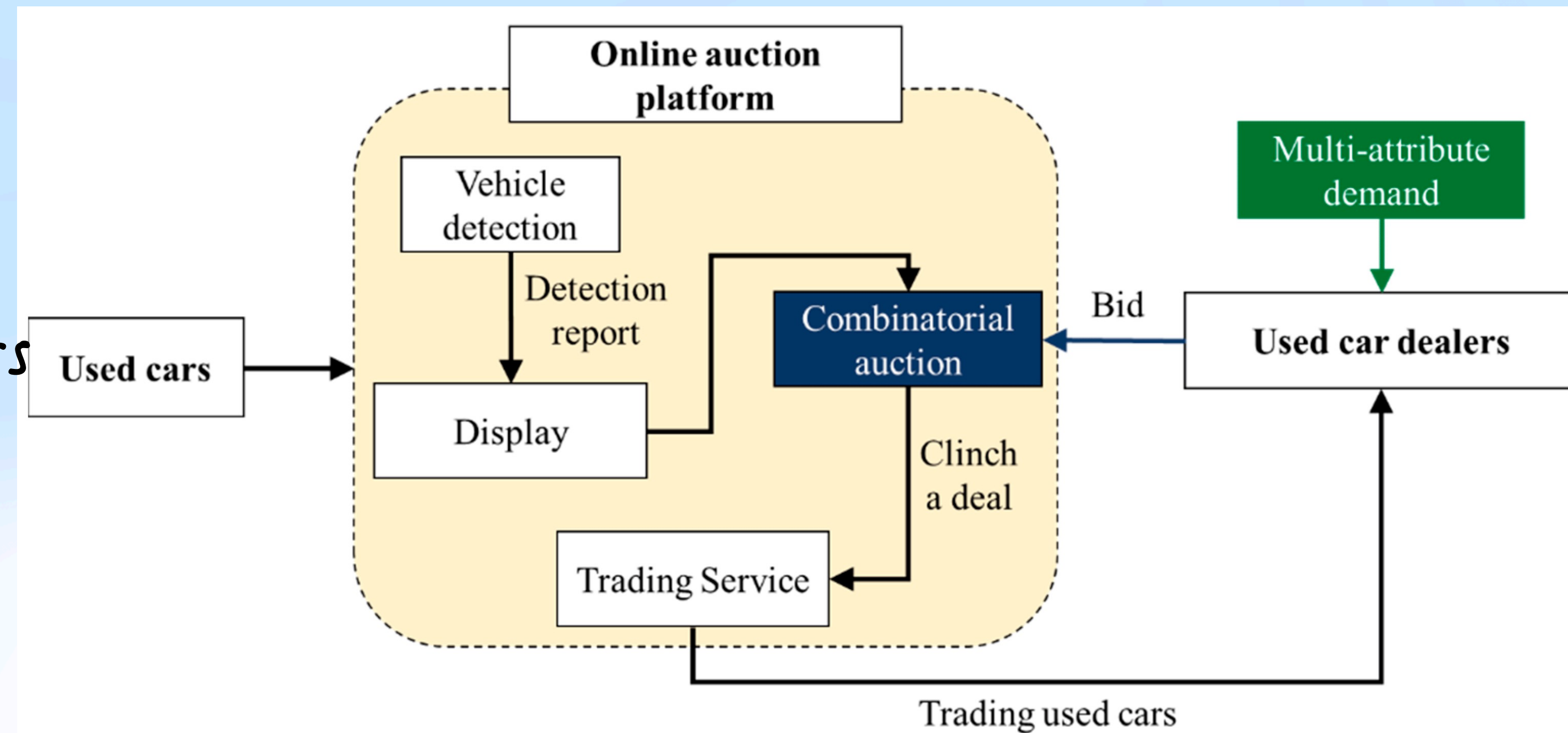
Eg. truckload transportation, bus routes, industrial procurement, rights to mine natural resources, allocation of radio spectrum for wireless communications.

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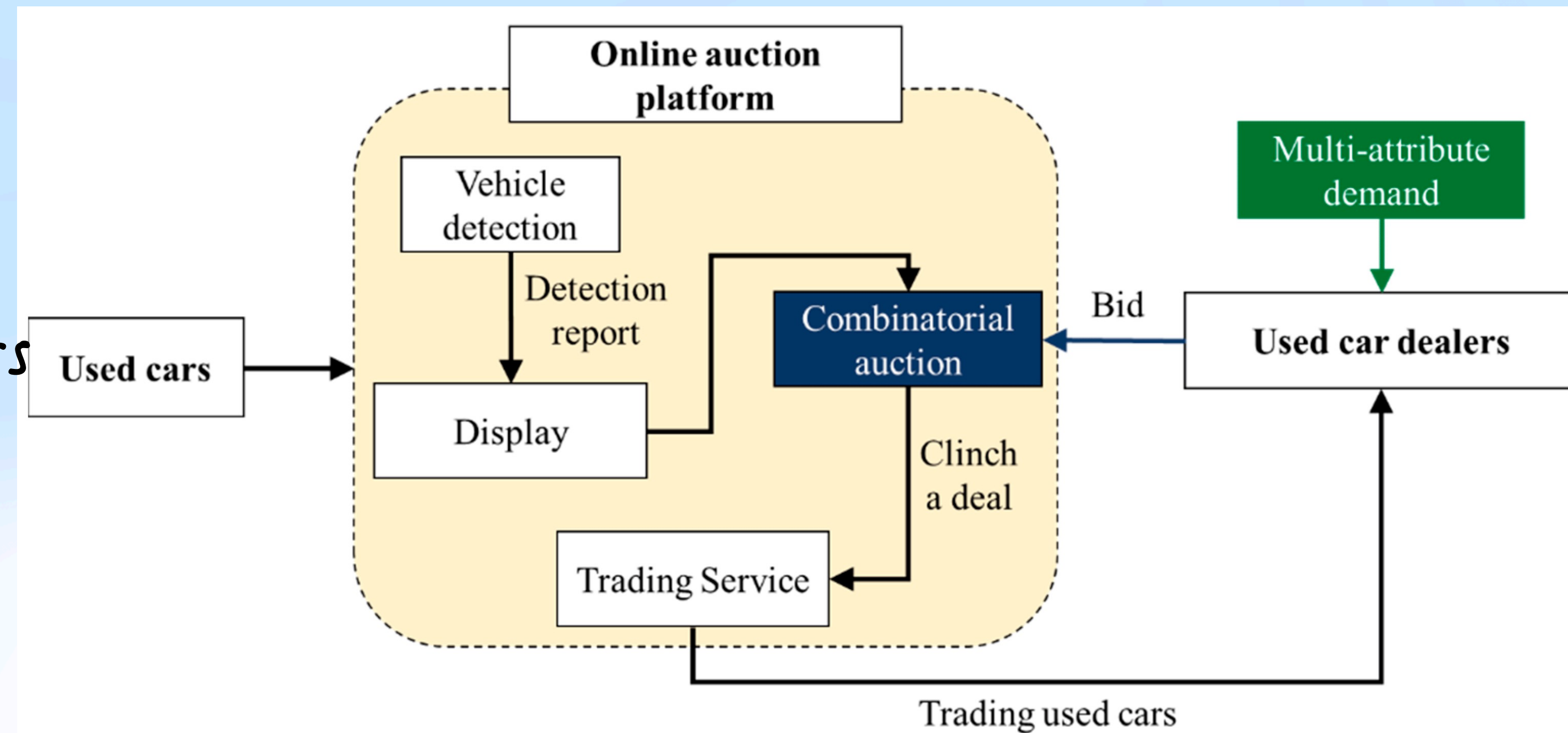


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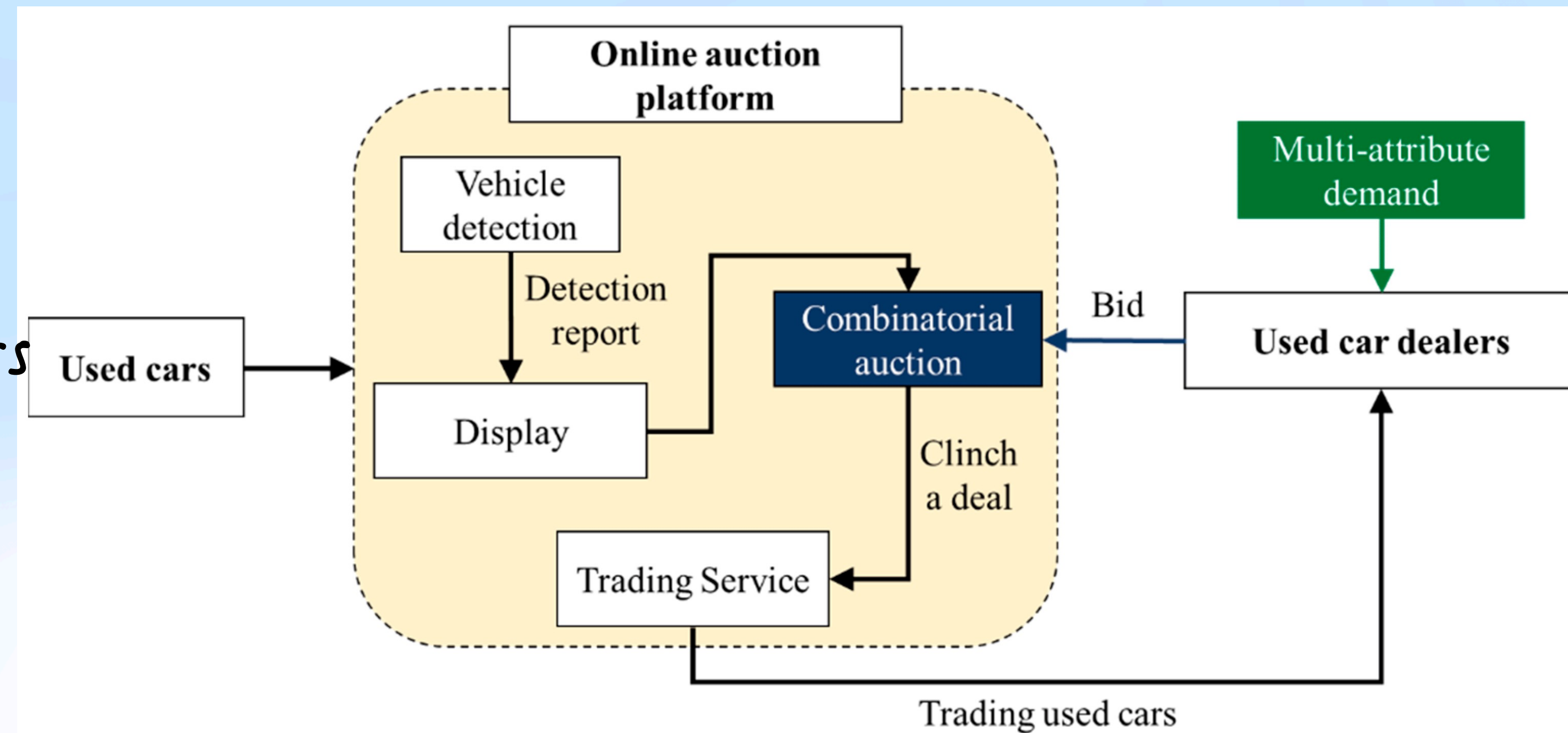
2. Multiple challenges are encountered:

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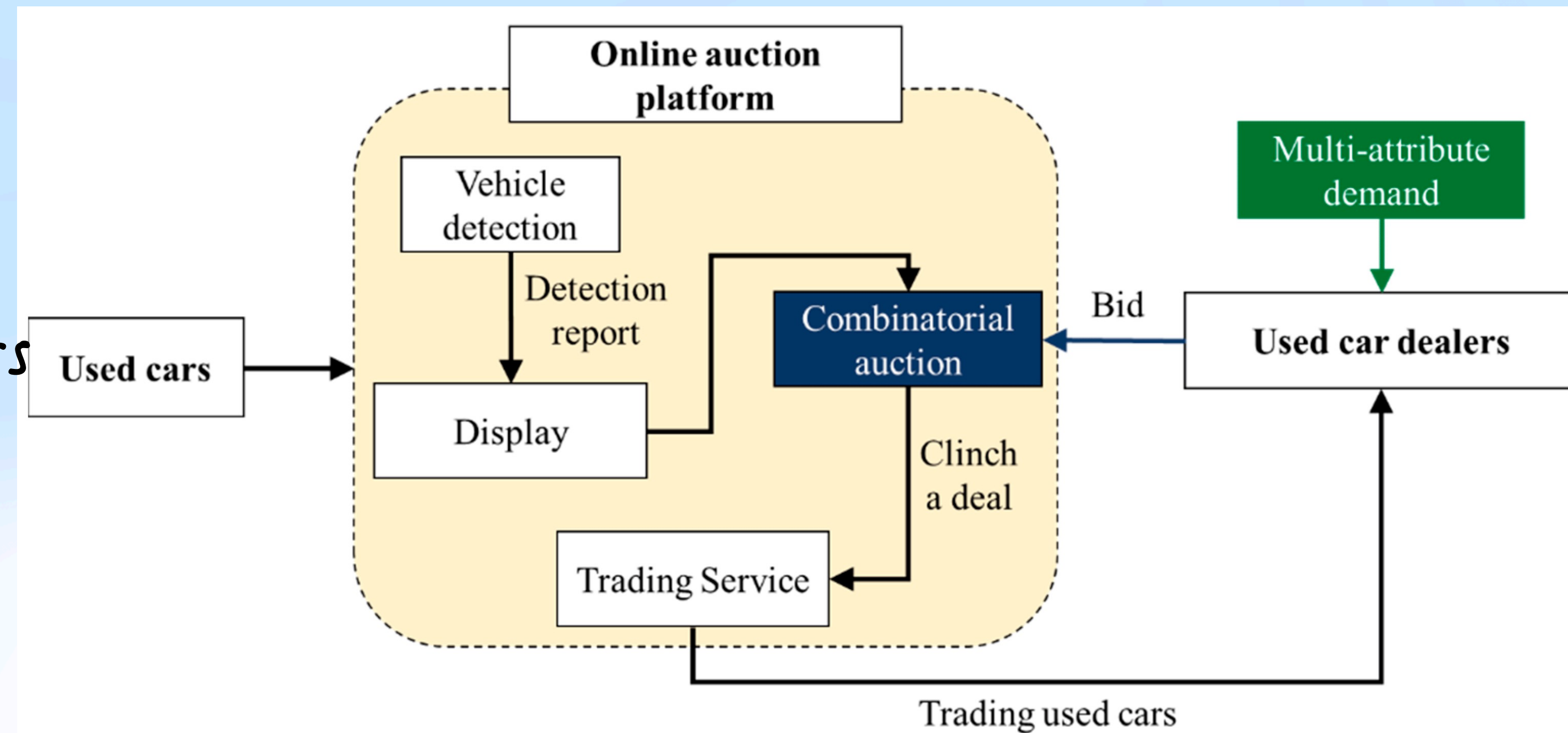
2. Multiple challenges are encountered: *How to allocate items ?*

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2. Multiple challenges are encountered:

How to allocate items ?

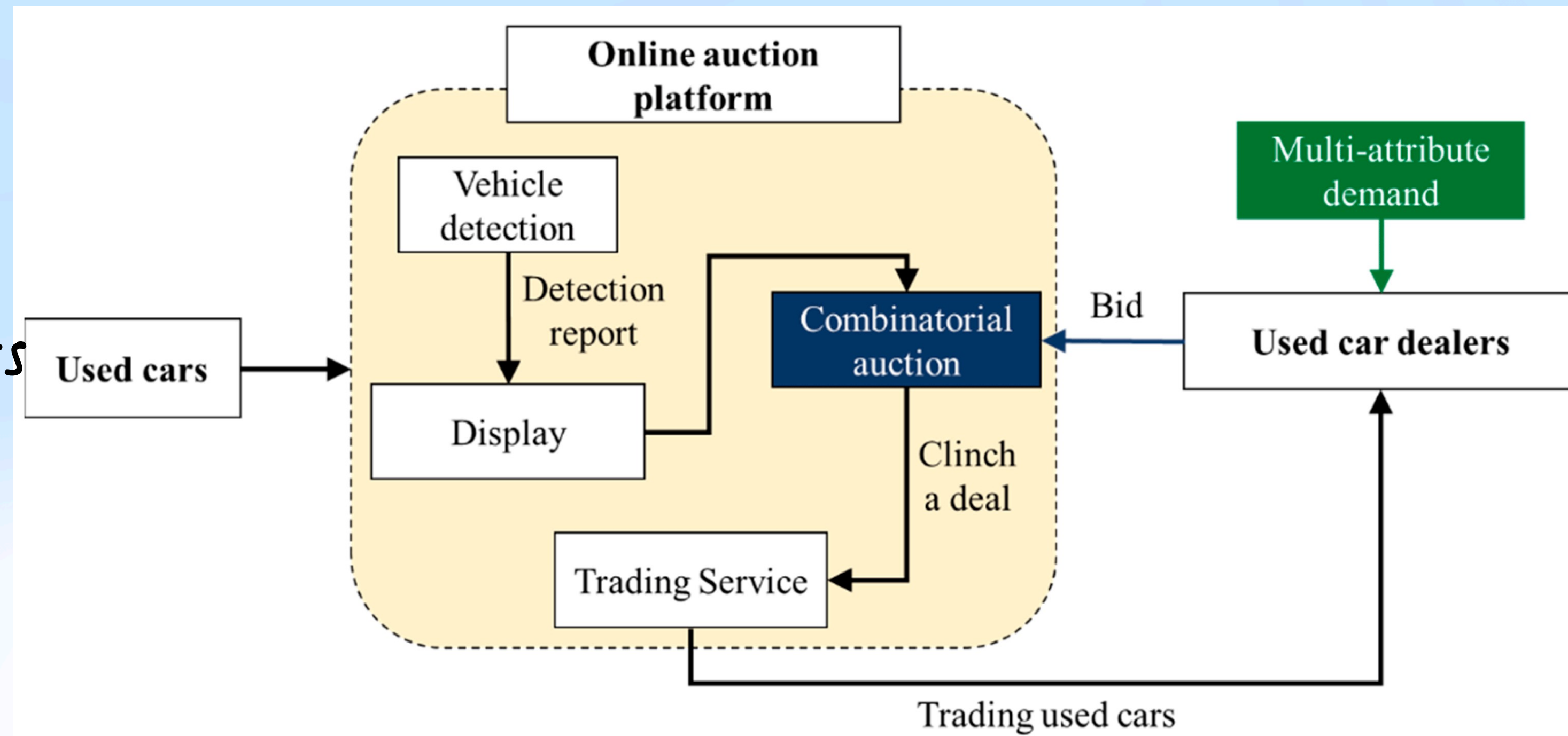
Whom to allocate to ?

Other complex (and complicated) auctions

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2. Multiple challenges are encountered: *How to allocate items ?* *Whom to allocate to ?*

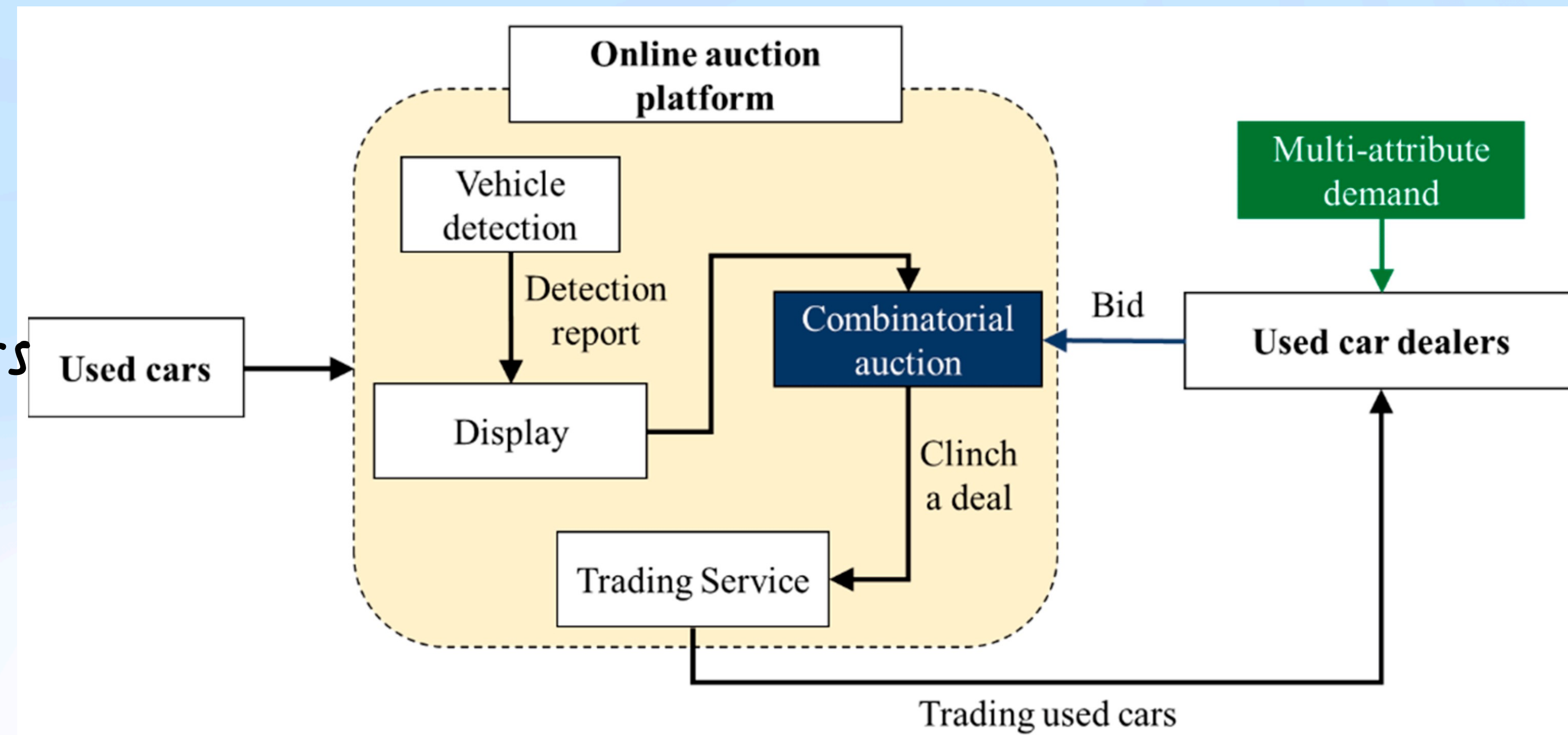
These are computationally hard problems!

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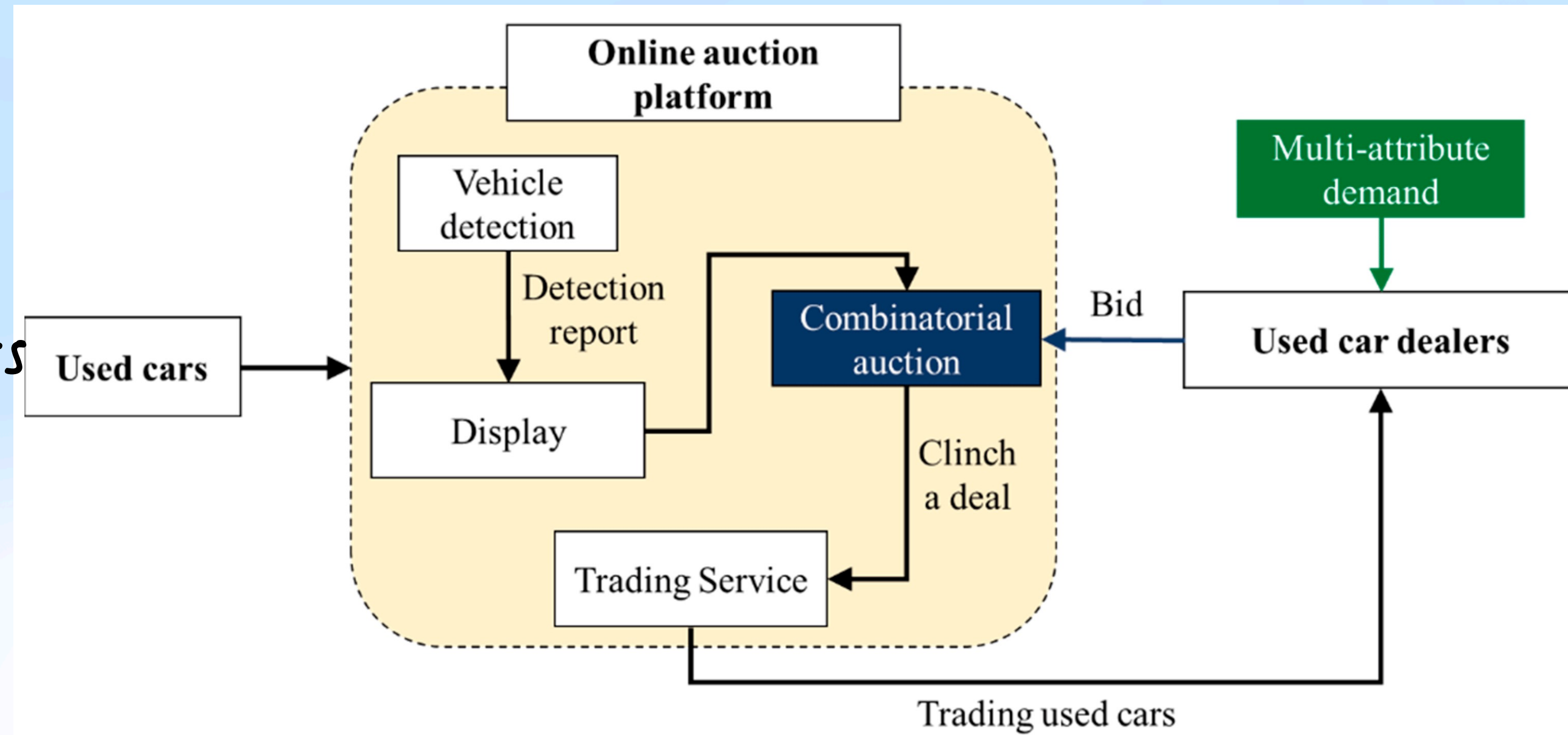
Knapsack

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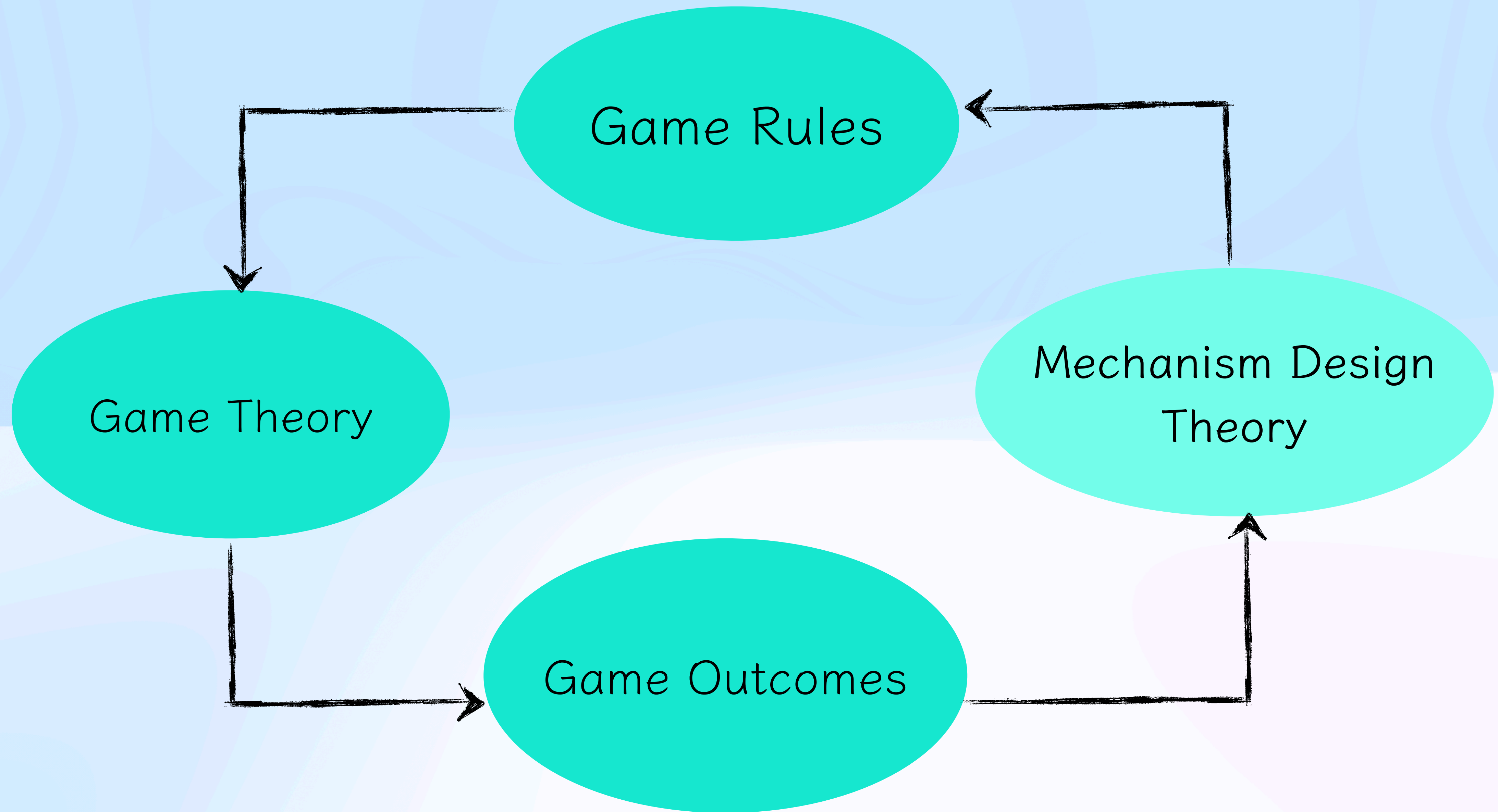
2. Multiple challenges are encountered: *How to allocate items ?* *Whom to allocate to ?*

These are computationally hard problems!

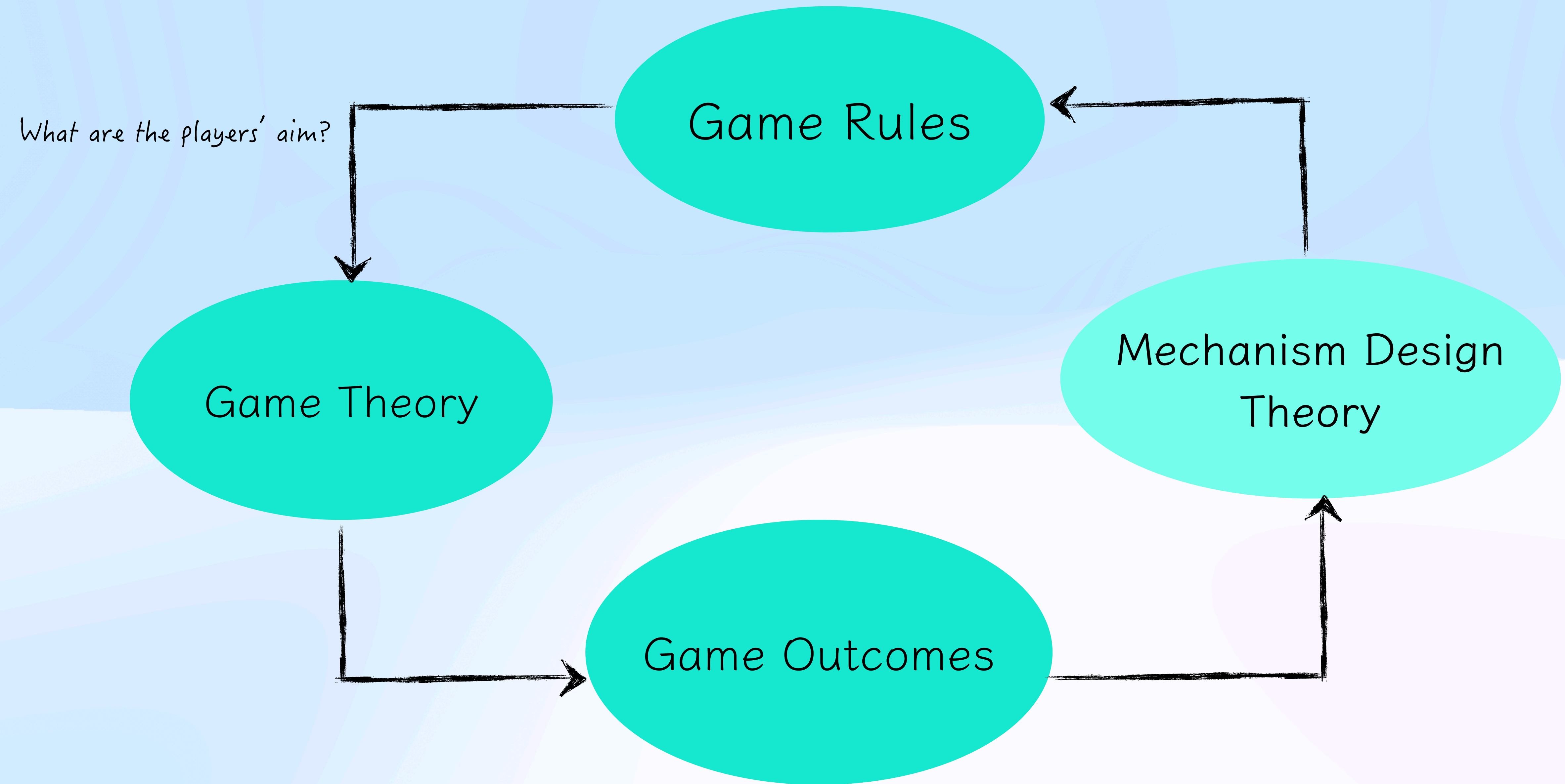
Knapsack

Packing

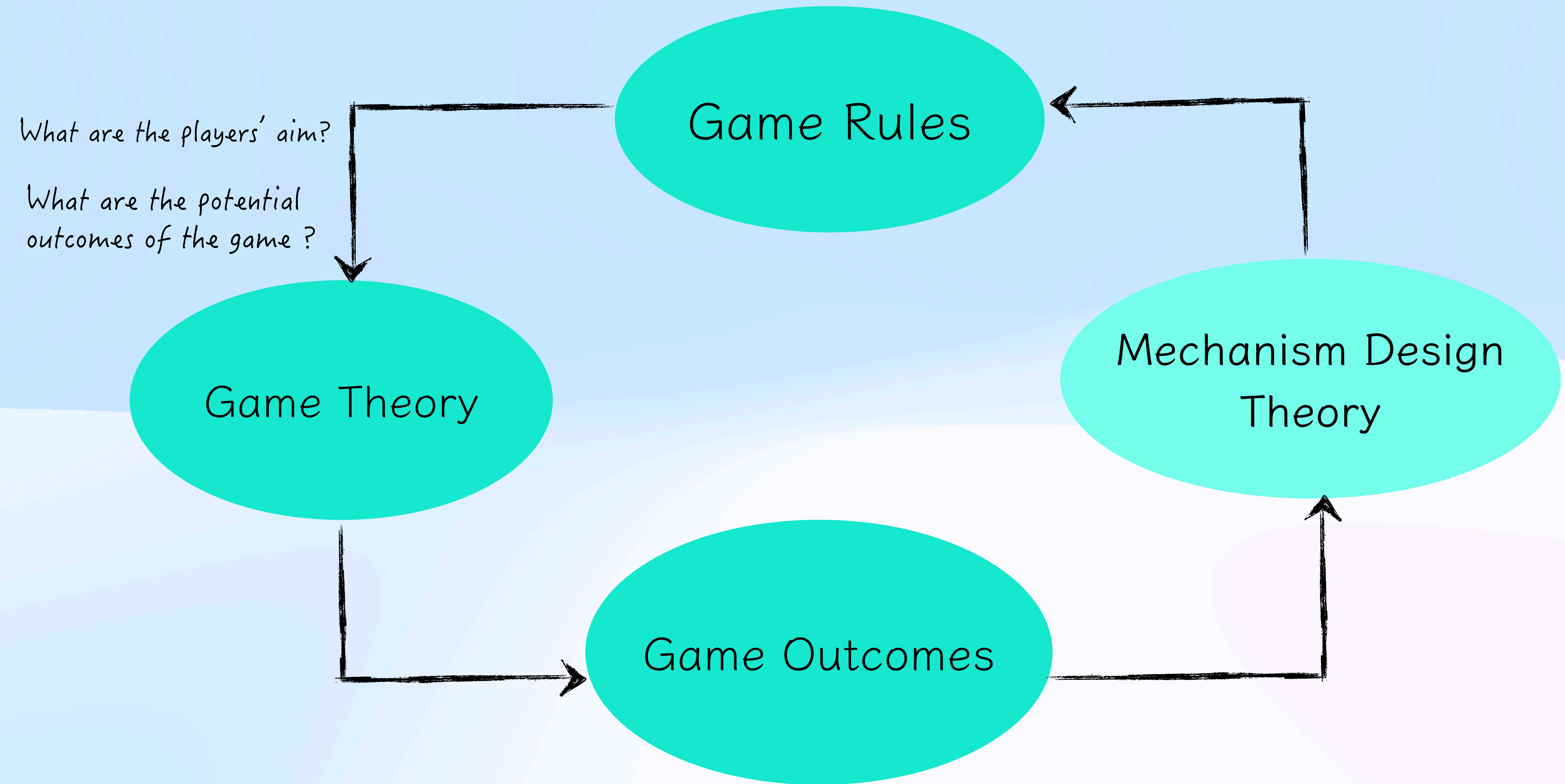
Game Theory vs Mechanism Design



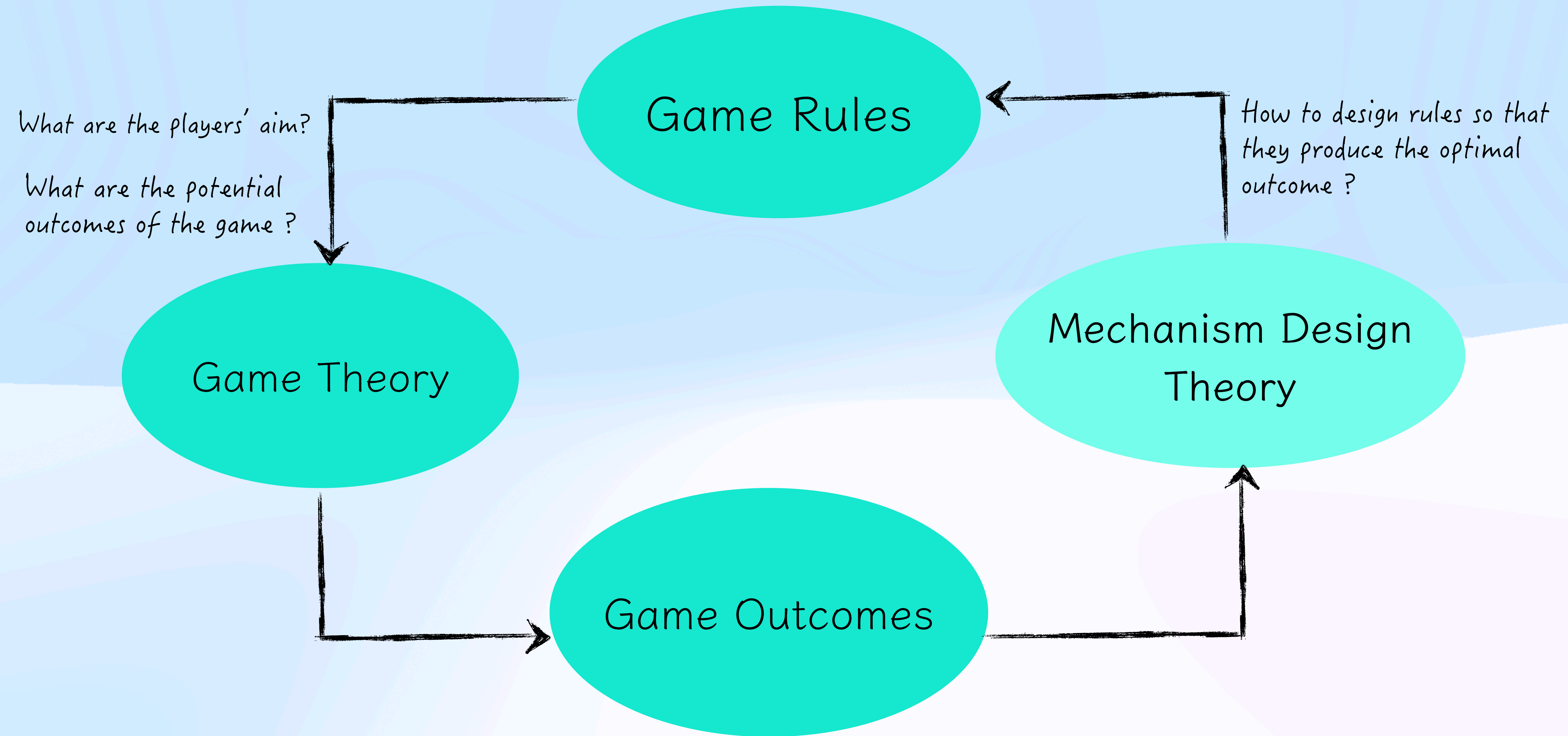
Game Theory vs Mechanism Design



Game Theory vs Mechanism Design



Game Theory vs Mechanism Design



Before we conclude ...

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1. Sponsored Search and the revenue it generated birthed billion dollar enterprises.

That in turn birthed the Internet Marketplace

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2. It necessitated computational efficiency in executing economic theories.

Millions of searches every second and the resulting computational questions led to the growth of a field called Algorithmic Game Theory and Mechanism Design

Before we conclude ...

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That in turn birthed the Internet Marketplace

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Millions of searches every second and the resulting computational questions led to the growth of a field called Algorithmic Game Theory and Mechanism Design

3. Algorithmic questions about auctions richly contributed to the growth of this field and continues to seed new ideas to date.

Computational efficiency and its tradeoff with quality is the guiding light of theoretical computer science and is the central conundrum in real-world auctions.

Thank You!