

# Unmanned Aerial Systems Coordinate Target Allocation Based on Wolf Behaviors



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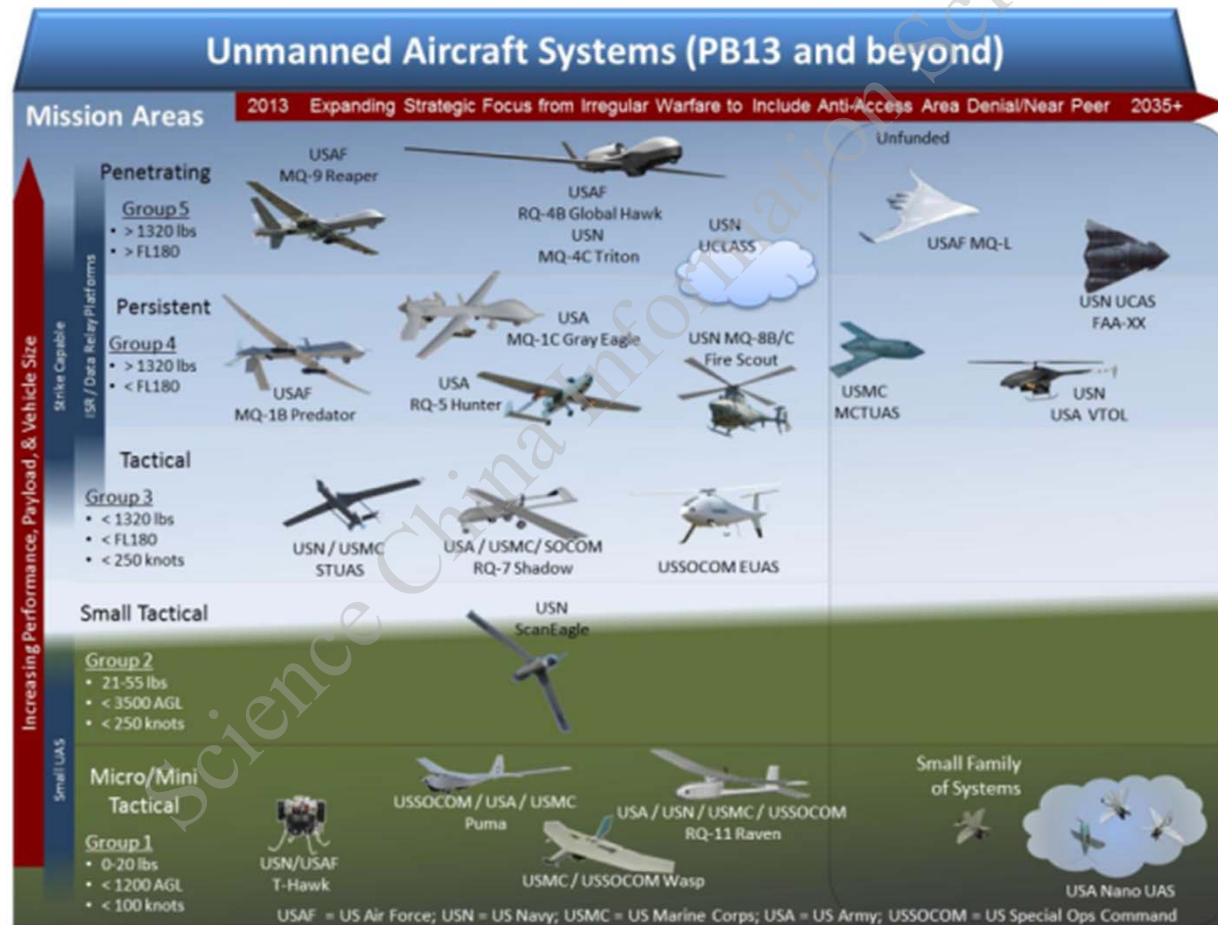
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# Unmanned Aerial Systems Coordinate Target Allocation Based on Wolf Behaviors



- UAS have the advantages of zero casualties, high-speed overload, excellent stealth performance, short operational preparation time, relatively low life-cycle cost, which has been developed at a fast speed in recent years.





## Wolf behaviors



- The wolf, one of the most cunning and cruel predator. There is a complex hunting rule and process in wolves' hunting. When hunting coordinately, especially when killing large-scale prey that is several times their weight, wolves take turns to attack prey and wear it down.





## Wolf mechanism



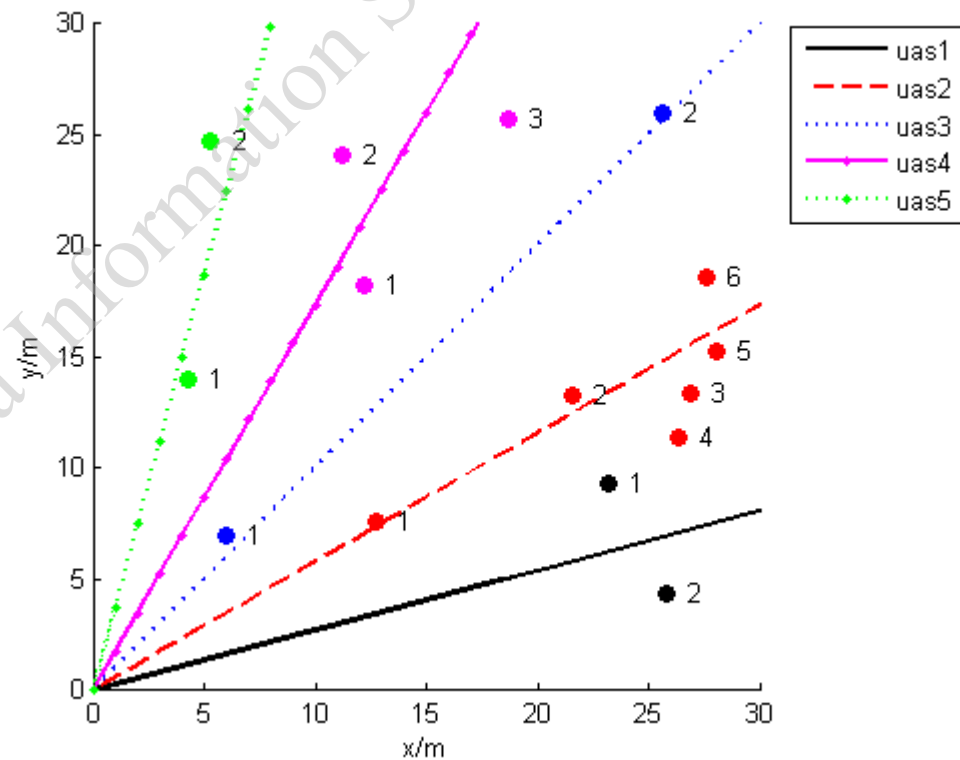
- In the beginning of a hunting, wolves are going to chase after prey along a trajectory defined by a paw function. A wolf usually chase after prey near the trajectory.

If the coordinate of launch point is  $(0, 0)$ , the paw function is a function set as shown below:

$$P = \left\{ (x, y) \mid y = x \tan \frac{i\pi}{2(N+1)}, \right. \\ \left. i = 1, 2, \dots, N, x, y \in R^+ \right\} \quad (1)$$

where  $N$  is the quantity of UAS,  $i = 1, 2, \dots, N$ ,  $(x, y)$  is a coordinate in the curve of paw function. And the paw function distance is denoted as:

$$Dis_{paw} = k\sqrt{x^2 + y^2} + \\ \min(\sqrt{(x-x_0)^2 + (y-y_0)^2}, (x_0, y_0) \in P) \quad (2)$$





# Wolf mechanism



- The wolf requests the assistance to other wolves or responds to other wolves.

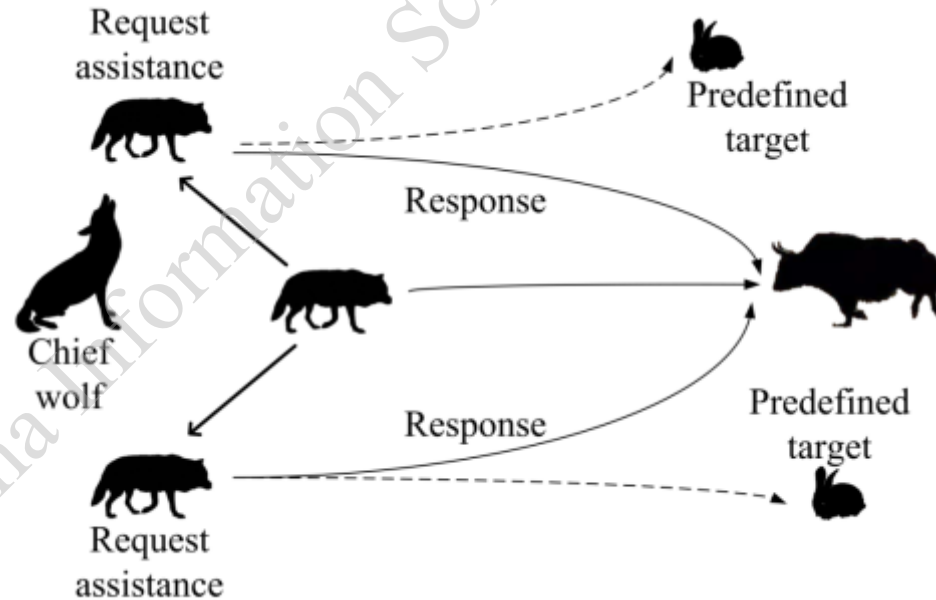
Whether a wolf deciding to request an assistance to other wolves or respond to other wolves depends on the variable below:

$$profit = dens + val \times \sum_{i=1}^k harm_i \quad (3)$$

$$cost = \sum_{i=0}^k f_i \quad (4)$$

$$fit = cost - profit \quad (5)$$

$$k = \arg \max(fit) \quad (6)$$

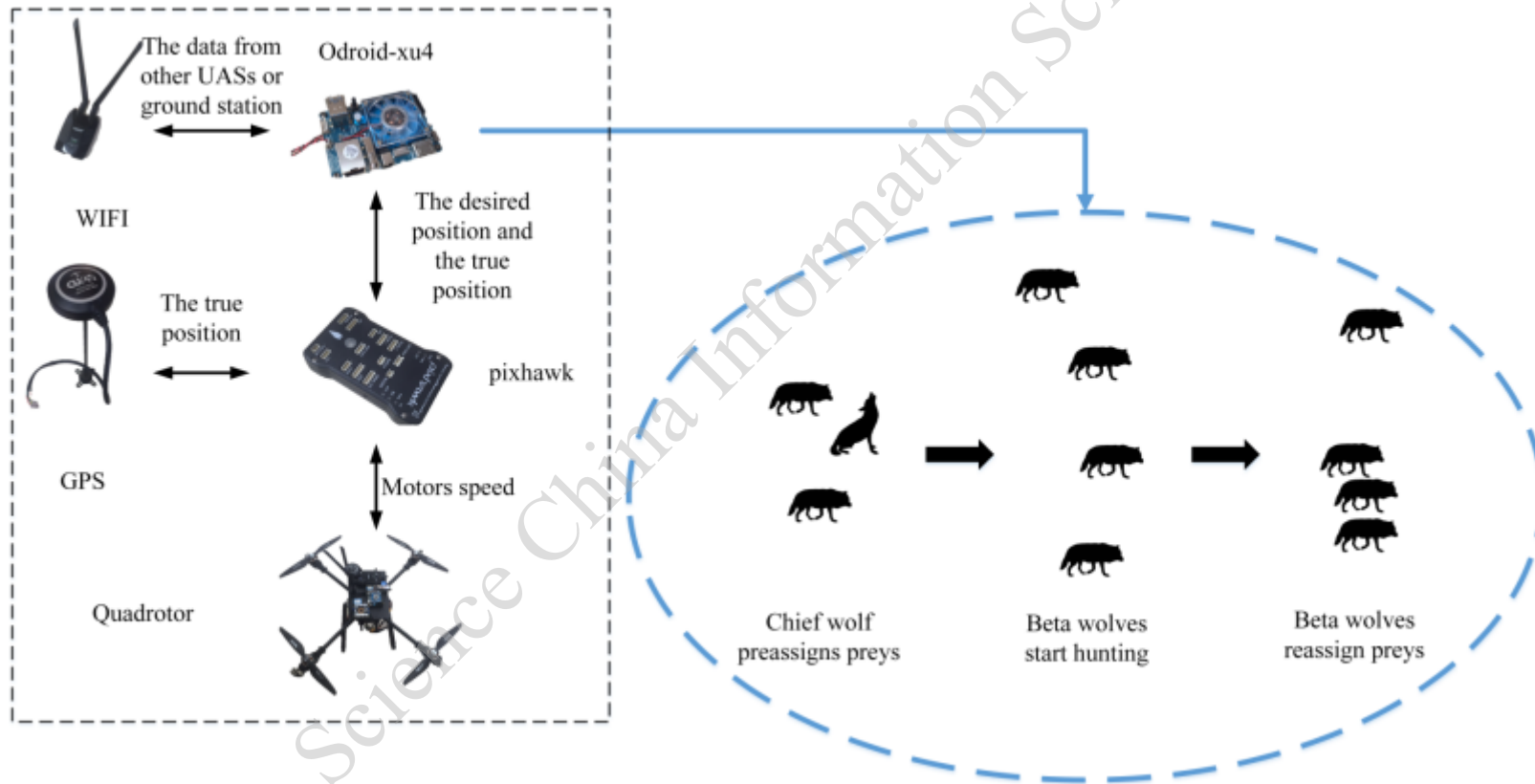




# Unmanned aerial systems architecture



- The framework of the unmanned aerial systems is shown below. A quadrotor has a Linux computer which conducts the wolf mechanisms.

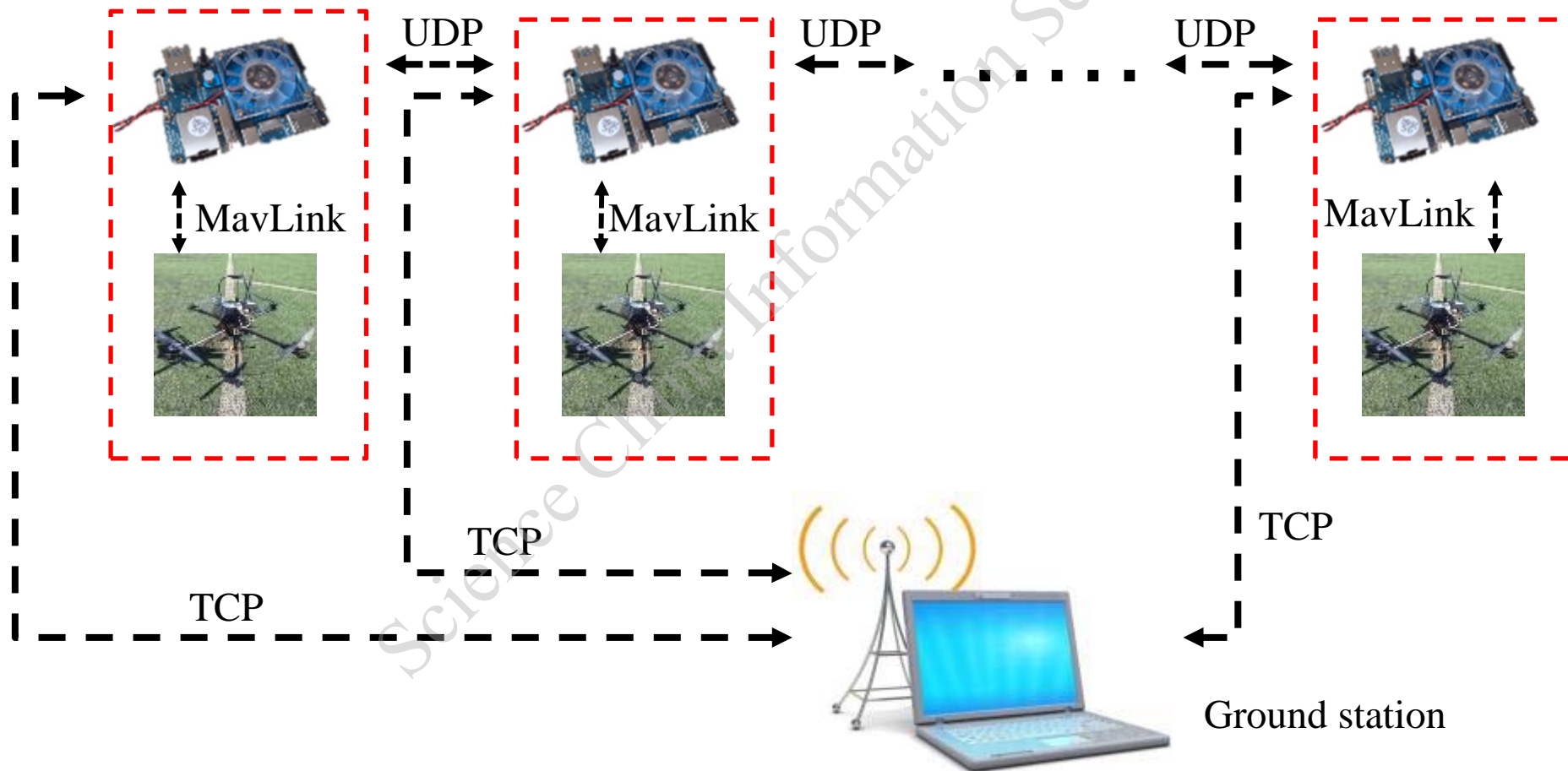




# Unmanned aerial systems architecture



- A ground station sends a command to UAS on automatic take-off and landing by transmission control protocol(TCP). During the targets assignment, UAS connects to each other by user datagram protocol(UDP).

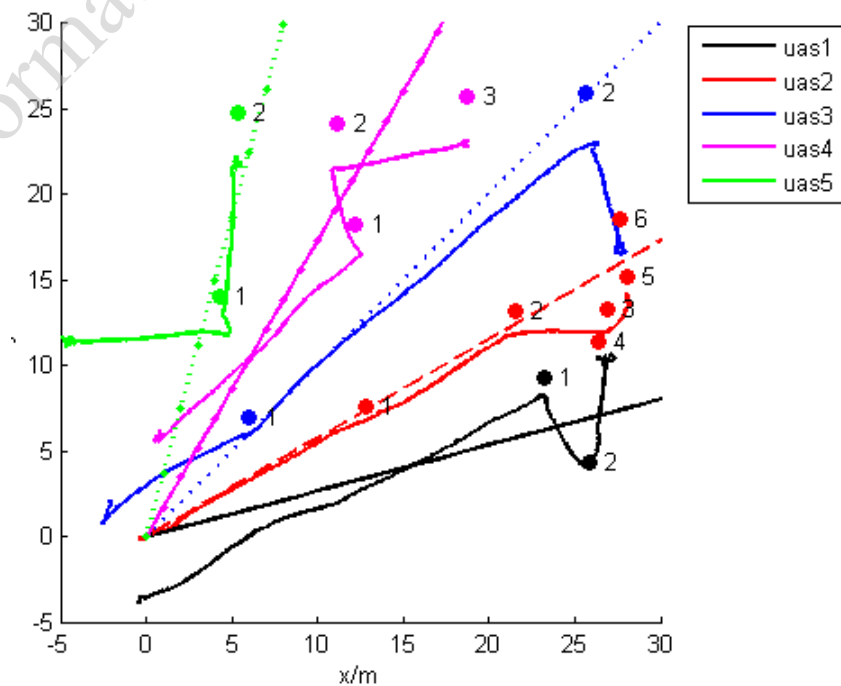
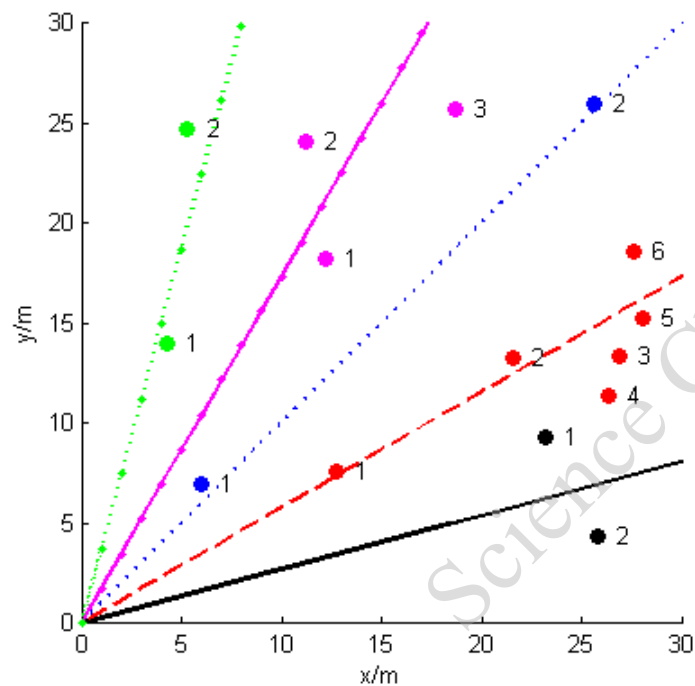




## Flight outside experiment



- In the experiment, a computer on the ground sends a command on take-off to all the quadrotors.
- In the beginning, the quadrotors have a series of predefined targets by calculating their priority.
- During the process, the quadrotors reassign the targets by calculating their profit and cost.
- After finish all the task, the quadrotors land automatically.







# Flight outside experiment





# Flight outside experiment



× 2





## Conclusion and future prospects



- The targets assignment based on wolf mechanism has been verified on five UAS.
- In the future, we will develop more than five UAS to verify the targets assignment based on wolf mechanism.
- In the future, we will do other research about wolf mechanism and verify it in the UAS.



**Thanks for  
Your Attention!**

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