Sapien Staking Multiplier Model

Sapien AI

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1 Multiplier Formula

The Sapien staking multiplier is calculated using a multiplicative approach that combines both staking amount and lockup time into a unified bonus system:

$$M_{final} = M_{base} + \frac{x \times B_{max}}{10000} \tag{1}$$

Where:

$$x = \frac{A_{norm} \times T_{norm}}{10000} \tag{2}$$

And:

- $M_{base} = 1.00$ (10000 basis points)
- A_{norm} is the normalized amount (0 to 10000 basis points)
- T_{norm} is the normalized time (0 to 10000 basis points)
- $B_{max} = 0.50$ (5000 basis points maximum bonus)
- x is the combined effect of amount and time
- M_{final} ranges from 1.00x to 1.50x (10000 to 15000 basis points)

2 Normalization

Both staking amount and lockup time are normalized to basis points (0-10000) based on their respective maximum values:

2.1 Amount Normalization

$$A_{norm} = \frac{A \times 10000}{A_{max}} \tag{3}$$

Where:

- A is the staked amount in tokens (clamped to A_{max} if exceeded)
- $A_{max} = 2500$ tokens
- A_{norm} ranges from 0 to 10000 basis points

2.2 Time Normalization

$$T_{norm} = \frac{T \times 10000}{T_{max}} \tag{4}$$

Where:

- T is the lockup period in seconds (clamped to T_{max} if exceeded)
- $T_{max} = 365$ days = 31,536,000 seconds
- T_{norm} ranges from 0 to 10000 basis points

3 Combined Effect Calculation

The key innovation in this model is the multiplicative combination of amount and time effects:

$$x = \frac{A_{norm} \times T_{norm}}{10000} \tag{5}$$

This creates a synergistic effect where:

- Small amounts with short lockups yield minimal bonus
- Large amounts with short lockups yield moderate bonus
- Small amounts with long lockups yield minimal bonus
- Large amounts with long lockups yield maximum bonus

4 Bonus Calculation

The final bonus is calculated as:

$$B_{final} = \frac{x \times B_{max}}{10000} \tag{6}$$

Where:

- x is the combined effect (0 to 10000)
- $B_{max} = 5000$ basis points (0.50x)
- B_{final} ranges from 0 to 5000 basis points

5 Example Calculations

5.1 Minimum Stake, Minimum Time (1 token, 30 days)

$$
\begin{aligned}
A_{norm} &= \frac{1 \times 10000}{2500} = 4 \\
T_{norm} &= \frac{30 \times 86400 \times 10000}{31536000} = 821 \\
x &= \frac{4 \times 821}{10000} = 0.33 \\
B_{final} &= \frac{0.33 \times 5000}{10000} = 0.16 \\
M_{final} &= 10000 + 0.16 = 10000.16 \approx 10000
\end{aligned}
$$

5.2 Medium Stake, Medium Time (1000 tokens, 180 days)

$$
\begin{aligned}
A_{norm} &= \frac{1000 \times 10000}{2500} = 4000 \\
T_{norm} &= \frac{180 \times 86400 \times 10000}{31536000} = 4932 \\
x &= \frac{4000 \times 4932}{10000} = 1973 \\
B_{final} &= \frac{1973 \times 5000}{10000} = 986 \\
M_{final} &= 10000 + 986 = 10986
\end{aligned}
$$

5.3 Maximum Stake, Maximum Time (2500 tokens, 365 days)

$$
\begin{aligned}
A_{norm} &= \frac{2500 \times 10000}{2500} = 10000 \\
T_{norm} &= \frac{365 \times 86400 \times 10000}{31536000} = 10000 \\
x &= \frac{10000 \times 10000}{10000} = 10000 \\
B_{final} &= \frac{10000 \times 5000}{10000} = 5000 \\
M_{final} &= 10000 + 5000 = 15000
\end{aligned}
$$

6 Visualization

7 Key Properties

1. **Base Reward**: All stakers receive a base 1.00x multiplier

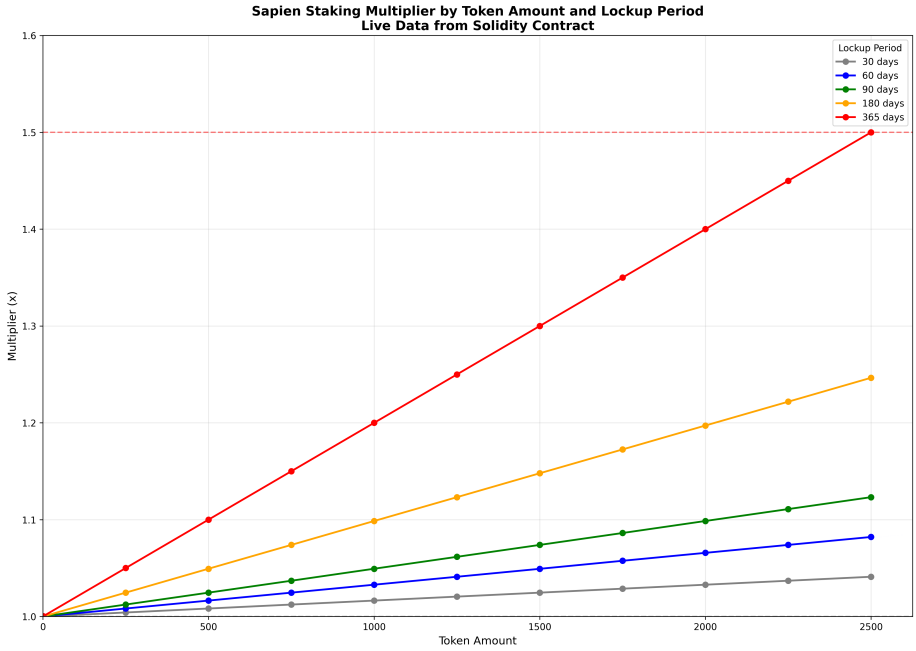

Figure 1: Sapien Staking Multiplier Surface showing the relationship between staked amount and lockup time. The multiplicative nature creates a curved surface where the maximum 1.50x multiplier is only achievable through the combination of maximum stake (2500 tokens) and maximum lockup (365 days).

2. **Multiplicative Synergy**: Amount and time bonuses multiply together, creating stronger incentives for combining both
3. **Progressive Scaling**: Higher multipliers require significant commitment in both dimensions
4. **Maximum Reward**: The maximum 1.50x multiplier requires both maximum stake (2500 tokens) and maximum time (365 days)
5. **Continuous Scaling**: The multiplier scales continuously based on the product of normalized inputs
6. **Input Clamping**: Amounts above 2500 tokens and lockups above 365 days are clamped to maximum values

8 Implementation Notes

The multiplier is implemented in Solidity using basis points (1.00x = 10000):

- Base multiplier: 10000 basis points (1.00x)

- Maximum tokens: 2500×10^{18} wei
- Maximum lockup: 365 days = 31,536,000 seconds
- Maximum bonus: 5000 basis points (0.50x)
- Final multiplier range: 10000-15000 basis points (1.00x-1.50x)

The calculation ensures that:

- Inputs are clamped to maximum values to prevent overflow
- All calculations use integer arithmetic to avoid floating-point precision issues
- The combined effect creates natural incentive alignment for long-term, high-value staking