Wow Reforged project - Items scaling

Heisen

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About the subject

A few words to explain my approach. Two years ago, I developed a few tools to help a friend with an other wow custom project (Rochenoire). One of these tools consisted of an item scaling system. The idea was to change item stats to modify its own level. It might be helpfull to you :

- To properly scale item within the 1-10 level of your project
- To create new balance items

This item scaling system doesn't work below level 10.

Most of the ideas developed here are certainly well known. Since I use custom notation and abreviation, I need to define them properly.

To end this introduction, it's very likely that this document contains errors. I'll be pleased fix them, so let me know.

1 The vanilla wow item system

This system is complex and intertwine, but quite understandable with a few rules in mind. It highly relies on budget points spent to give stats to items and item level.

1.1 Item Level

The item level, wich will be refer as Ilvl, is an hidden number. It is used to calculate the budget points that can be used to create an item and get the required level to be able to use an item.

Usualy, requiered level (refered as Rlvl) and Ilvl :

$$\text{Rlvl} = \text{Ilvl} - 5$$

Unfortunatly, it doesn't work with end game items in high level donjon or raid items. So, a method to compute this Ilvl is required. This method is explain below.

1.2 Item quality, item slot and armor

Items are classified according to their quality, slot where they must be used and armor.

1.2.1 Item quality

Item quality is the item color :

Quality	Poor	Common	Uncommon	Rare	Epic	Legendary
Color	gray	white	green	blue	purple	orange
Data base number	0	1	2	3	4	5

1.2.2 Item slot and armor

To compute items stats, item are gathered in subgroup. A multiplying factor is associate to each of these subgroup :

Slot	Slot mod
Head, Chest, Legs, 2H weapon	1
Shoulders, hands, waist, feet	0.75
Wrist, neck, back, finger, off-hand, shield	0.56
1H weapon	0.42
Ranged weapon	0.32
Trinket	0.7

Armor items are also classified according to their armor type :

Armor type
Neck, trinket, finger and cloak
Cloth
Leather
Maille
Plate
Weapon
Shield

1.3 Items stats

There is two kind of stats :

- Type A : those whose value are calculate with a single formula and depend on quality, armor and slot. Example : armor value or weapon DPS.
- Type B : those whose value depend on item budget points. Example : Agility, strength, stamina, hit chance or spell power.

Needless to say that the first kind of stats is very easy to compute, meanwhile the second kind is much more tricky.

2 Type A stats formula

In this section, we are going to review and summarize how to calculate each type A stats : Amor, block value and weapon DPS.

2.1 Armor

Armor value only depends on Ilvl, quality and slot. It can be calculate from the base amore value given here : [Datasheet]

$$\text{Armor value} = \text{Base Armor} \times \text{Armor Slot Mod}$$

Armor slot	Amor slot mod
Chest	16/16
Legs	16/16
Head	16/16
Shoulder	12/16
Feet	12/16
Hands	12/16
Waist	12/16
Wrist	9/16
Back (always cloth)	9/16

2.1.1 Shield

There is no simple formula to get armor and block value of a shield. So, data extrapolate from database are sum up here : [Datasheet]

2.1.2 Bonus Armor

Some items get a bonus armor. This bonus may be hidden, he is include within the armor value. This bonus armor is a type B stats.

2.2 Weapon DPS

Weapon DPS calculation formula is less tricky than armor values.

2.2.1 1h weapons

- Grey :

  $$\text{DPS} = 2.37 + 2.68 \times 10^{-2}\text{Ilvl} + 9.32 \times 10^{-3}\text{Ilvl}^2 - 9.11 \times 10^{-5}\text{Ilvl}^3 + 3.29 \times 10^{-7}\text{Ilvl}^4$$

- White :

  $$\text{DPS} = 0.926 + 0.324\text{Ilvl} + 3.53 \times 10^{-3}\text{Ilvl}^2 + 4.07 \times 10^{-5}\text{Ilvl}^3 - 4.93 \times 10^{-7}\text{Ilvl}^4$$

- Green :

$$\begin{cases} \text{Ilvl} < 35 : & \text{DPS} = 0.52\text{Ilvl} - 0.17 \\ \text{Ilvl} \geq 35 \text{ and Ilvl} < 46 : & \text{DPS} = 0.9\text{Ilvl} - 13.9 \\ \text{Ilvl} \geq 46 : & \text{DPS} = 0.58\text{Ilvl} + 1 \end{cases}$$

- Blue :

$$\begin{cases} \text{Ilvl} < 32 : & \text{DPS} = 0.518\text{Ilvl} + 3.14 \\ \text{Ilvl} \geq 32 \text{ and Ilvl} < 42 : & \text{DPS} = 0.88\text{Ilvl} - 8.08 \\ \text{Ilvl} \geq 42 : & \text{DPS} = 0.613\text{Ilvl} + 2.7 \end{cases}$$

- Purple :

$$\text{Ilvl} = 1.467 + 1.092\text{Ilvl} - 1.333 \times 10^{-2}\text{Ilvl}^2 + 1.135 \times 10^{-4}\text{Ilvl}^3$$

2.2.2 2h weapons

- Grey :

$$\text{DPS} = 4.21 - 0.109\text{Ilvl} + 1.8 \times 10^{-2}\text{Ilvl}^2 - 2.09 \times 10^{-4}\text{Ilvl}^3 + 8.23 \times 10^{-7}\text{Ilvl}^4$$

- White :

$$\text{DPS} = 5.92 - 0.201\text{Ilvl} + 3.14 \times 10^{-2}\text{Ilvl}^2 - 3.83 \times 10^{-4}\text{Ilvl}^3 + 1.57 \times 10^{-6}\text{Ilvl}^4$$

- Green :

$$\text{DPS} = 1.3\text{DPS of a 1H green weapon}$$

- Blue :

$$\text{DPS} = 0.865\text{Ilvl}$$

- Purple :

$$\text{DPS} = 1.975 + 1.426\text{Ilvl} - 1.766 \times 10^{-2}\text{Ilvl}^2 + 1.509 \times 10^{-4}\text{Ilvl}^3$$

Note 1 : that these datas come from linear regression of DPS in database. There must be more straightforward relation. They might be a bit off, but it won't be an issue.

Note 2 : These relation fail to calculate caster weapon DPS. We need to introduce a DPS sacrifice to explain both DPS value and spell and healing bonus.

2.3 TO DO : caster and heal weapon - DPS sacrifice

2.3.1 TO DO : ranged weapon and wands

2.4 How to use these formula

Our main goal is scaling an item from any level to any other lvl (above lvl 10). You might have noticed that same Ilvl weapon might have different but close DPS. I don't think that it's something intended by Blizzard, but it might come from some rounding errors. However, we should use the previous formula as a scaling system. For example, let's take a common weapon :

- Ilvl = 24
- speed : 1.6
- minimum damage : 13
- maximum damage : 26
- Genuine DPS $= \dfrac{\max + \min}{2\text{speed}} = 12.2\text{DPS}$

The previous formula gives : theoretical DPS = 12.3. If we want to scale this weapon Ilvl 50, the Scaled theoretical DPS = 30.0.

So, the Scaled real DPS should be given by :

$$\text{Scaled real DPS} = \frac{GenuineDPS \times \text{Scaled theoretical DPS}}{\text{theoretical DPS}} = 29.8$$

Since only damages are in the data base, we should apply the same logic to min and max damages. Armor and block values scaling should be calculated the same way[1].

- Weapon damages :

$$\text{Scaled Damage} = \frac{GenuineDamage \times \text{Scaled theoretical DPS}}{\text{theoretical DPS}}$$

- Armor values :

$$\text{Scaled Armor} = \frac{GenuineArmor \times \text{Scaled theoretical Armor}}{\text{theoretical Armor}}$$

- Block values :

$$\text{Scaled Block} = \frac{GenuineBlock \times \text{Scaled theoretical Block}}{\text{theoretical Block}}$$

[1]Keep in mind that armor might be off due to armor bonus. These bonus are easy to spot since the armor value is way too far from the theoretical value.

3 Type B stats

Previously, we explained how to calculate type A stats. These does not depends on a particular design. That means, for example, that every single rare plate helmet Ilvl 60 will have the exact same amount of armor. These stats comes from a generic construction.

On the contrary, type B stats belong to the item design. It has been chosen to build an item with x strenght, y stamina and z spirit. The complexity rely on the rules which stress the amount of a particular stats an item can have.

The goal of this section is explaining those rules and draw a procedure to scale these stats to build blizzlike item.

3.1 budgets points : BP

An amount of stats budget points are given to each item. This budget is calculated from Ilvl and Slot mode coefficients (1.2.2).

$$\text{Ilvl} = \text{SM} \cdot (A \cdot \text{BP} + B)$$

A and B depend on the quality item :

Quality	A	B
Green	2	7
Blue	1.75	1.69
Green	1.46	1.2

Once again, these data comes from a linear regression of item stats. They might be off but it won't be an issue.

The main issue is that we can't use these relation to get budget points of each items from Ilvl in database. It seems that Blizzard followed roughly its own rules, so we will have to compute the real budget point of each item to be able to properly scale it.

3.2 Budget points and stats

Let's call S_1, S_2 and so on, the item stats of an item. The relation between BP and stats is :

$$BP^{\alpha} = S_1^{\alpha} + S_2^{\alpha} + S_3^{\alpha} + \dots$$

Let's have a look at the Nightsky Armor, a green chest :

For a green item, $\alpha = 1.5$, this give :

$$BP = (8^{\alpha} + 8^{\alpha} + 8^{\alpha})^{\frac{1}{\alpha}} = 16.6$$

And :

$$\text{Ilvl} = 2 \cdot BP + 7 \approx 40$$

The database Ilvl is 37 which is close, but not the same. Therefor some items appear to be stronger or weaker than they should be. And if we want to keep it that way through any scaling process, the budget point need to be calculated.

3.3 Stats weighting : SW

Stats	Weight : SW
Intel	1
Spirit	1
Strength	1
Stamina	1
Agility	1
Bonus armor	0.1
Def	1.5
mp5	2.5
hp5	2.5
Spell damage	0.86
Spell Damage (single school)	0.7
Heal	0.45
Attack power	0.5
Attack Power (single creature type)	0.33
Magic penetration	0.9
Resistance (one school)	1
Resistance (all school)	2.5
1% Dodge	12
1% block	5
hit	10
spell hit	8
crit	14
spell crit	14
Parry	20

Each stats weight differently :

$$BP^{\alpha} = (W_1 \cdot S_1)^{\alpha} + (W_2 \cdot S_2)^{\alpha} + (W_1 \cdot S_3)^{\alpha} + \dots$$

For example, that's why you can get much more healing bonus than spell bonus on items. Healing bonus weight half the spell bonus.

4 Scaling process

To be continued...