

# **Bancor Protocol**

## **Continuous Liquidity and Asynchronous Price Discovery for Tokens through their Smart Contracts; aka “Smart tokens”**

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The phrase "double coincidence of wants" was coined by Jevons (1875). "The first difficulty in barter is to find two persons whose disposable possessions mutually suit each other's wants. There may be many people wanting, and many possessing those things wanted; but to allow of an actual act of barter there must be a double coincidence, which will rarely happen."

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# The Bancor Protocol

*Abstract: The Bancor protocol enables built-in price discovery<sup>1</sup> and a liquidity mechanism for tokens on smart-contract blockchains. These “smart tokens” hold one or more other tokens in reserve, and enable any party to instantly purchase or liquidate the smart token in exchange for one of its reserve tokens, directly through the smart token’s smart-contract, at a continuously calculated price, according to a formula which balances buy and sell volumes.*

The Bancor protocol is named in honor of the Keynesian proposal<sup>2</sup> to introduce a supranational reserve currency called Bancor to systematize international currency conversion after World War II.

## Background

We live in a world where anyone can publish an article, song or video, create a discussion group and even run an online marketplace. We are now beginning to witness the emergence of user-generated currencies. Different types of stored-value (“currencies” hereafter) have been issued and circulated for centuries in the form of bank notes, bonds, equity, gift-cards, loyalty points, community currencies<sup>3</sup> and others. Bitcoin was the first *decentralized* digital currency, followed by a wave of new cryptocurrencies that have been issued since, and recently we’ve seen the rise of a new asset class of “tokens” that are typically issued in crowdsales (“ICOs”) through smart contracts.

However, currencies, which are essentially [networks of value](#), do not connect to each other in the same way that information networks do. While the switches on Internet exchange points (IXs) interlink information networks - the active traders on *exchanges* are effectively interlinking currencies.

The current exchange model for currencies/assets has a critical barrier, as a certain volume of trading activity is required to achieve market-liquidity. This inherent barrier makes it nearly impossible for small-scale currencies (such as community currencies, loyalty-points or other custom tokens) to be linked (exchangeable) to other popular currencies using a market-determined exchange rate.

In the age of smart-contract blockchains, tokens can be automatically managed by immutable code which controls their issuance and behavior. We realized this could mean allowing tokens to hold balances of other tokens (i.e. “reserves”), directly through their smart contracts, that could be designed by their creators and managed programmatically. These new technological capabilities warrant rethinking of the possible solutions for converting one currency to another and determining market prices.

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<sup>1</sup> [https://en.wikipedia.org/wiki/Price\\_discovery](https://en.wikipedia.org/wiki/Price_discovery)

<sup>2</sup> <https://en.wikipedia.org/wiki/Bancor>

<sup>3</sup> [https://en.wikipedia.org/wiki/Community\\_currency](https://en.wikipedia.org/wiki/Community_currency)

## Introducing Smart Tokens: A Solution to the Liquidity Problem

Smart tokens are standard ERC20 tokens which implement the Bancor protocol, providing continuous liquidity while automatically facilitating price-discovery. The smart token's contract instantly processes *buy* and *sell* orders, which drive the price-discovery process. Due to this capability, smart tokens do not need to be traded in an exchange in order to become liquid.

A smart token holds a balance of least one other *reserve token*, which (currently) can be a different smart token, any ERC20 standard token or Ether. Smart tokens are issued when purchased and destroyed when liquidated, therefore it is always possible to purchase a smart token with its reserve token, as well as to liquidate a smart token to its reserve token, at the current price.

### A New Method for Price Discovery

A smart token utilizes a novel method for price-discovery which is based on a "Constant Reserve Ratio" (CRR). The CRR is set by the smart token creator, for each reserve token, and used in price calculation, along with the smart token's current supply and reserve balance, in the following way:

$$Price = \frac{Balance}{Supply \times CRR}$$

This calculation ensures that a constant ratio is kept between the reserve token balance and the smart token's market cap. Dividing the market cap by the supply produces the price according to which the smart tokens can be purchased and liquidated through the smart-contract. The smart token's price is denominated in the reserve token and readjusted by the smart contract per each purchase or liquidation, which increases or decreases the reserve balance and the smart token supply (and thus the price) as detailed below.

When smart tokens are purchased (in any of their reserve currencies) the payment for the purchase is added to the reserve balance, and based on the calculated price, *new smart tokens are issued* to the buyer. Due to the calculation above, a purchase of a smart token with a less than 100% CRR will cause its price to increase, since both the reserve balance and the supply are increasing, while the latter is multiplied by a fraction.

Similarly, when smart tokens are liquidated, they are *removed from the supply* (destroyed), and based on the current price, reserve tokens are transferred to the liquidator. In this case, for a smart token with a CRR less than 100%, any liquidation will trigger a price decrease.

This asynchronous price discovery model works by constantly readjusting the current price toward an equilibrium between the purchase and liquidation volumes. While in traditional exchanges the price is determined by two matched orders in *real-time*, smart token prices are calculated *over-time*, following every order.

The above formula calculates the current price, however, when a purchase or liquidation is executed, the effective price is calculated as a function of the transaction size. The calculation

can be described as if every transaction is broken up into infinitely small increments, where each increment is changing the smart token's supply, reserve balance, and thus its price. This ensures that purchasing the same amount of smart tokens in a single or multiple transactions would yield the same total price. Additionally, this method ensures that the CRR will be kept constant and the reserve can never be drained. Essentially, the effect of the transactions size on the price (due to its changing the smart token's supply and reserve balance) is incorporated into the effective price for any transaction. The mathematical functions for calculating price per transaction size are presented further in this document.

## Use-Cases for Smart Tokens

### The Long tail<sup>4</sup> of User-Generated Currencies

The long tail phenomena can be observed in many different online ecosystems such as publishing (blogs), videos (YouTube), discussion forums (Reddit, Facebook Groups) and more. In each of these examples, the long tail has become significantly larger in scale than everything that preceded it. The forming of a long tail begins as soon as the barriers to its existence are removed (e.g. YouTube making it simple for anyone to upload and share user-generated videos).

There are many examples of user-generated-currencies, such as community currencies (community oriented currencies), loyalty points (business oriented currencies), and the most recent being hundreds of cryptocurrencies (protocol oriented currencies). However, the need to achieve and maintain liquidity for these small or new currencies remains a significant barrier for their viability.

Smart tokens are unique in that they can be purchased or liquidated by a single party, using the calculated price, *removing the need for two wants to be simultaneously matched*. This effectively means that by using the Bancor protocol, small-scale currencies with a low expected trade volume can offer continuous liquidity, thus, removing the barrier for them to be linked to the global economy.

Enabling the long-tail of currencies is likely to bring about a new generation of creative use-cases. Though it's improbable to predict all of them, some of the more likely use-cases are listed below.

### Crowdfunding a Project

The crowdfunding space has been growing rapidly. Smart tokens can be used for crypto crowdfunding initiatives, where the participants receive tokens which are liquid and market-priced. For example, a musician may collect funds to record an album, which would be sold online exclusively in exchange for the issued tokens. A successful album would generate high demand for the tokens, driving up their price and rewarding those holding them. Many other examples exist such as crowdfunding a venture capital fund or raising initial capital for a credit-creating neighborhood currency.

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<sup>4</sup> [https://en.wikipedia.org/wiki/Long\\_tail](https://en.wikipedia.org/wiki/Long_tail)

## Token-Changers

Token-changers are smart tokens that can be used to exchange between other standard ERC20 tokens. Token-changers hold multiple reserves-tokens, with a total CRR of 100%. A token-changer is designed to provide an exchange service between its reserve tokens (a two-step action of purchasing the smart token with one reserve token, and immediately liquidating it for another.)

Due to the price calculation formula, each time reserve token X is converted to reserve token Y -- the price of X decreases, while the price of Y increases. Larger transactions would move the price more sharply, however, a higher reserve balance would reduce price volatility.

As noted, any standard ERC20 token can be used as a reserve even if they are already traded in one or more classic or decentralized exchanges. In such a scenario, a price gap may open between the calculated price of a reserve token and its price in an outside exchange. This situation would *incentivize arbitrageurs to realign the price difference*, exactly as occurs when price gaps open up between different exchanges, thus keeping the token-changer prices in sync with the prices in which the tokens are traded in other exchanges.

A token-changer's creator may set a conversion fee that would apply on each purchase/liquidation. The fees are being accumulated in the reserves and thus increase the smart token's price with every token conversion taking place, increasing the smart token's value. This increase will benefit the holders of the smart token, who may have deposited the original reserves when the smart token was created, or purchased it with any of its reserve tokens at any time after that.

Popular exchanges such as MtGox and Bitfinex have been hacked with hundreds of millions of dollars worth of assets stolen from their accounts. Converting one token to another using a token-changer does not require depositing funds in an exchange and thus removes the counterparty risk from the process. Another important benefit is that no transaction limits need to be applied, as is the case with other instant-trading solutions, due to the decentralized nature of the token changer.

## Decentralized Token Baskets

Smart tokens can be used as decentralized token-baskets, which function similar to ETFs or index funds, simply by holding a portfolio of reserve tokens with a total CRR of 100%. As prices of any of the reserve tokens rise or fall, so does the value of the smart token. Similar to token-changers, here as well arbitrageurs are incentivized to realign the conversion rates with market prices which ensures the proper ratios are kept between the reserves according to their real-time market value. This enables users to directly hold asset baskets, without a financial services provider intermediary.

## Network Tokens

A collection of smart tokens that use the same reserve token form a *network of tokens*. The common reserve token can be described as a *network token* which captures the combined value of the network. An increased demand for any of the smart tokens in the network would propel

the demand for the network token, since it is required for purchasing these tokens and then held in their reserve. This would drive up the price of the network token, which *benefits the entire network* since the value of the tokens' reserves increases. The network-token also functions as a "token for tokens", rendering all the smart tokens in the network inter-changeable.

Network tokens can be useful for those who wish to roll out multiple and related, smart tokens, for different purposes (e.g. Regional network of community currencies, a video game studio with multiple game credits, a group of independent businesses issuing a joint loyalty program). The network token model creates synergetic relationships between the member tokens, comparable to the way a single successful Ethereum service would drive up the value of Ether, benefiting *all of its holders*.

An additional network token usecase is to interlink a set of token changers, where each of them holds a 50% CRR in the network token, and 50% CRR in another standard token. This structure would enable exchanging any token in the network to another, while increasing the demand for the network token whenever a new token changer is created or appreciates.

## Advantages of Smart Tokens

Smart tokens introduce multiple advantages over the traditional exchange model:

1. **Continuous Liquidity** - Since purchasing and liquidating is done through the smart contract - smart tokens are always liquid, irrespective of their trading volume.
2. **No Extra Fees** - The only mandatory fees applied by a smart token are the blockchain platform fees (Gas) which are relatively low.
3. **No Spread** - Since the price calculation is done algorithmically by the smart token, the same price applies for purchasing and liquidating the smart tokens.
4. **Predictable Price Slippage** - Smart tokens allow pre-calculation of the precise price slippage, based on the transaction size, before it is executed.
5. **Lower Volatility** - A smart token with 10% CRR (for example) is comparable to an exchange with 10% of the *entire supply* in the order-book at all times, forming substantial market depth. In a typical crypto exchange, the share of the supply in the market depth at any given moment is well below 1%. The higher the CRR, the lower the volatility. The lower the CRR, the more "new credit" is created relative to the original reserve amount.

## The Bancor Protocol Ecosystem

Different parties can take on different roles in the Bancor network ecosystem. The primary forms of participation are as follows:

- **End-Users** can receive, hold, transfer, request, purchase and liquidate tokens.
- **Smart Token Creators** issue new, always liquid smart tokens, that may be used for trading, token-changing, as token-baskets or as network-tokens.
- **Asset Tokenizers** (e.g. Tether-USD, Digix-Gold) issue ERC20 tokens representing external assets, thus enabling smart tokens to use these assets as reserve tokens (. Existing crypto-exchanges that operate under their local KYC regulations are well positioned to provide asset-tokenization services.)

- **Arbitrageurs** are organically incentivized to constantly reduce gaps between prices on crypto exchanges and Bancor network. Smart tokens work similarly to exchanges in that purchasing an asset increases its price and selling it decreases it, so that the same arbitrage mechanics and incentives apply.

## A Solution to the Coincidence of Wants Problem

The coincidence-of-wants problem<sup>5</sup>, in the current exchange model, creates a situation where assets are required to be traded at a certain minimal volume, or face a liquidity risk<sup>6</sup>. The cause for this limitation is that the chance of finding a second party with opposite wants to exchange with, correlates to the asset's trading activity level. Smart tokens solve this problem through the use of reserve tokens which embed market depth directly into the smart token's contract.

Smart tokens are a **technological solution** to the *coincidence-of-wants problem* for asset exchange, rather than a labor-based solution as used in traditional (or decentralized) exchanges. The current laborers in asset exchange are the professional market-makers who provide liquidity and facilitate collaborative price discovery. In the domains of information exchange and trade, the technologies of writing and currency replaced labor-intensive solutions (speaking and barter) with technological ones, creating mass efficiencies for societies and unlocking collaboration on a global and intergenerational level. The Bancor protocol proposes to similarly advance the domain of asset exchange by replacing the need for labor, with a technological solution to the existing coincidence-of-wants problem.

## Smart Token Initiation and Customization

New smart tokens can be created simply by depositing an initial reserve/s and issuing the initial token supply. Alternatively smart tokens can be initiated through a crowdsale, where a part of the proceeds is allocated as the initial reserve.

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<sup>5</sup> [https://en.wikipedia.org/wiki/Coincidence\\_of\\_wants](https://en.wikipedia.org/wiki/Coincidence_of_wants)

<sup>6</sup> [https://en.wikipedia.org/wiki/Liquidity\\_risk](https://en.wikipedia.org/wiki/Liquidity_risk)



# The Bprotocol Foundation

Bprotocol is a Swiss nonprofit foundation, whose core objective is the establishment of the Bancor protocol as a global standard for intrinsically tradeable currencies.

The Bprotocol Foundation will issue BANCOR - the first smart token to be deployed using the Bancor protocol, establishing the *BANCOR network*. The Foundation will collaborate with different contractors to achieve its goals, as well as governments, businesses, academics and NGOs committed to realizing collaboration potential in communities around the world.

## BANCOR - The First Smart Token

The BANCOR network token will hold a single reserve in Ether. Other smart tokens, by using BANCOR as (one of) their reserve(s), connect to the BANCOR network and become exchangeable to each other using the price discovery method outlined in this paper.

BANCOR network forms a monetary structure where increased demand for *any* of the network's tokens drives up the value of the common BANCOR token, benefiting *all* other smart tokens holding it in reserve. Naturally, it is also susceptible to downward price pressure by decreased demand.

BANCOR network will include user-generated currencies, token-changers (forming a global decentralized, highly liquid exchange), decentralized token baskets as well as and subnetworks.

BANCOR token will be issued in a crowdsale scheduled for May, 30, 2017. Additional details will be announced in early May.

## BANCOR Crowdsale Objectives

- A portion of the funds raised will be used as the Ether reserve for BANCOR (details on the CRR will be outlined in the offer memorandum), enabling continuous liquidity to Ether for any BANCOR holder, as well as any holder of a smart token using BANCOR as a reserve.
- A portion of the funds will be used to develop, promote and support the open-sourced, blockchain-agnostic, Bancor protocol implementations, and support related technologies and applications such as an open-source, user-friendly web service (desktop and mobile) to provide wallet, token-conversion, new smart token creation and crowdsale solutions.
- A portion of the funds will be used to set-up and fuel the first batch of token changers for popular ERC20 tokens, which function as a *decentralized solution for token exchange* between all the included tokens. This model introduces key advantages, incentivizing *asset tokenizers* to represent additional real-world assets as Ethereum tokens.
- A portion of the funds will be used to participate in and support innovative and promising future smart token crowdsales in the BANCOR network. This includes new, location-based and vertical-specific smart token initiatives such as regional token networks, community currencies, crowdfunded projects and other online or offline token-based ecosystems.

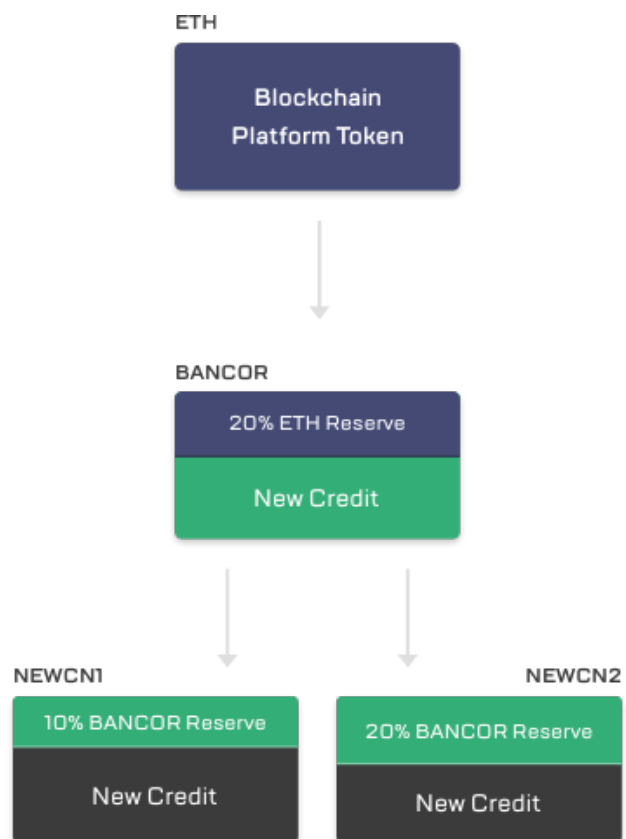
# Examples and Illustrations

## Example #1: Smart Token Transaction Flows

In this example, a crowdsale for a new token (BANCOR) has collected 300,000 ETH.

300,000 BANCOR are issued at a 1:1 ratio and transferred to the crowdsale participants. 240,000 ETH were directed towards funding the BANCOR project's development and 60,000 (20% CRR) were kept in the BANCOR smart contract as a reserve.

- Purchasing and liquidating BANCOR becomes possible as soon as the crowdsale is completed. The opening price is the last crowdsale price (in this example 1 ETH for the first BANCOR.)
- BANCOR liquidators get ETH from the reserve of BANCOR, the liquidated BANCORs are destroyed, and BANCOR price decreases respectively.
- BANCOR buyers get newly minted BANCORs, their payment in ETH is added to the smart contract reserve and the BANCOR price increases.



The ETH reserve always remains 20% of the BANCOR market cap by dictating how the current price is calculated.

Activity	ETH Received (Paid-out)	BANCOR Issued (Destroyed)	Effective Transaction Price	ETH Reserve	BANCOR Supply	BANCOR Market-cap	Current BANCOR Price	Price change
Post-crowdsale initial state				€60,000	300,000	€300,000	€1.0000	
300 ETH converted to BANCOR	€300	299	€1.0020	€60,300	300,299	€301,500	€1.0040	0.40%
700 ETH converted to BANCOR	€700	694	€1.0086	€61,000	300,993	€305,000	€1.0133	0.93%
1302 BANCOR converted to ETH	€(1,308)	(1,302)	€1.0046	€59,692	299,691	€298,460	€0.9959	-1.72%
100 ETH converted to the BANCOR	€100	100	€0.9966	€59,792	299,792	€298,960	€0.9972	0.13%

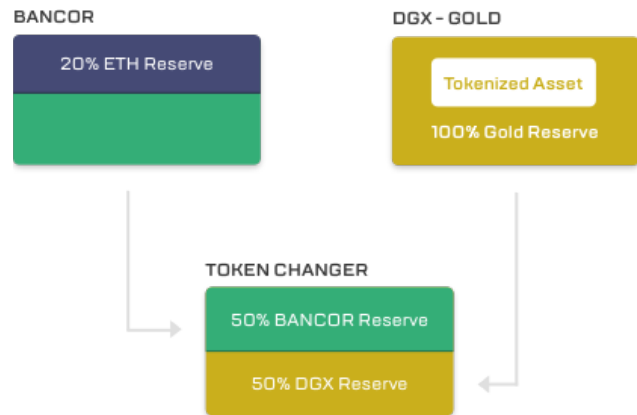
[Link to Spreadsheet](#)

## Example #2: Token Changer Transaction Flows

In this example, the BNCDGX smart token is created to function as a token-changer between BANCOR and DGX (Tokenized Gold), holding both in reserve with a 50% CRR each, for a total of 100% CRR.

Assuming a current market price of 1 BANCOR = 2 DGX, the contract can define the initial prices as 1 BANCOR = 2 DGX = 1 BNCDGX and in this example, 10,000 BNCDGX are issued to the depositors of the initial reserves.

- The opening prices are 1 BNCDGX = 1 BANCOR = 2 DGX as was set in the contract.
- The BNCDGX can be purchased with BANCOR or DGX. The BNCDGX price will increase for the reserve token it was purchased with (BANCOR or DGX), and decrease in the uninvolved reserve token (due to the increase in the BNCDGX supply).
- BNCDGX can be liquidated back to BANCOR or DGX, decreasing the BNCDGX price in the liquidated reserve token, and increasing it in the uninvolved reserve token.



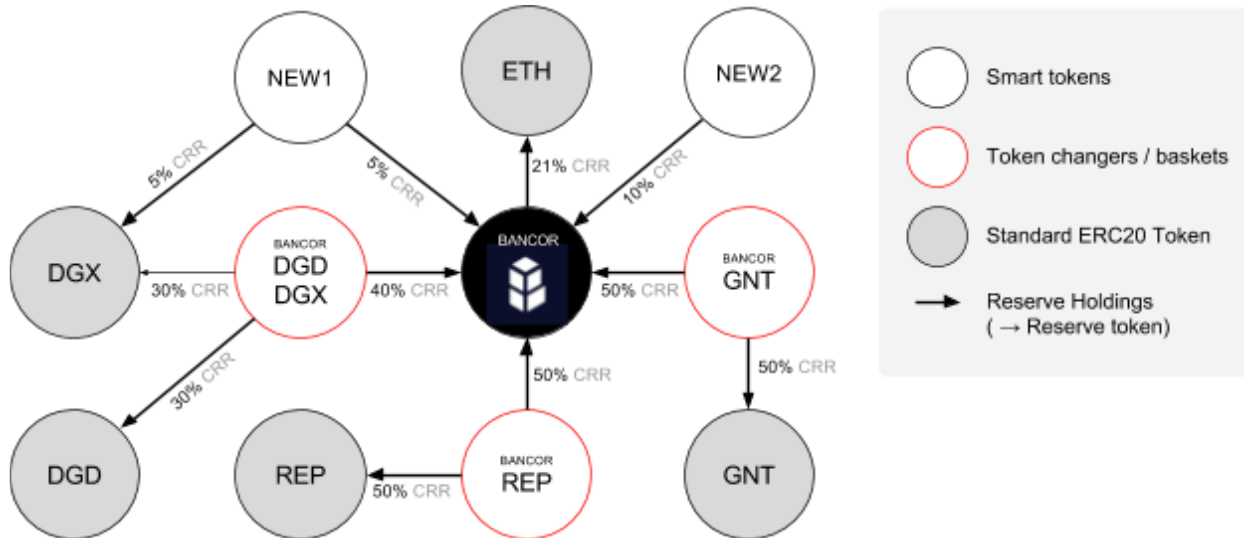
This scenario demonstrates how a 100% backed smart token with multiple reserve tokens can function as a decentralized token-changer, open for anyone to use, and be organically balanced by arbitrageurs. It can be described as a “decentralized ShapeShift”, as well as a “decentralized token-basket,” purchasable by anyone, and organically preserving its defined holdings ratios through the arbitrageurs.

BNCDGX Smart-token Symbol		BNCDGX									
Reserve-tokens		BANCOR + DGX									
Constant Reserve Ratio (CRR)	BANCOR	50%									
	DGX	50%									
Initial Token Price	BANCOR	1									
	DGX	2									
Deposited Reserves	BANCOR	5,000									
	DGX	10,000									
Activity		Reserve Recieved (Paid-out)	BNCDGX Issued (Destroyed)	Conversion Rate	Reserve Balance	BNCDGX Supply	BNCDGX Market-cap	BNCDGX Price per Reserve	BNCDGX Price change	1 BANCOR = DGX	
Initial state	BANCOR				5,000	10,000	10,000	1.000		0.500	
	DGX				10,000	10,000	20,000	2.000			
Buying BNCDGX for 30 BANCOR	BANCOR	30	30.0	1.0015	5,030	10,030	10,060	1.003	0.30%	0.503	
	DGX				10,000	10,030	20,000	1.994	-0.30%		
Converting 70 DGX to BANCOR Step 1 (DGX->BNCDGX)	BANCOR				5,030	10,065	10,060	1.000	-0.35%	0.500	
	DGX	70	35.0	1.9975	10,070	10,065	20,140	2.001	0.35%		
Converting 70 DGX to BANCOR Step 2 (BNCDGX->BANCOR)	BANCOR	(35.0)	(35.1)	1	4,995	10,030	9,990	0.996	-0.35%	0.496	
	DGX				10,070	10,030	20,140	2.008	0.35%		

[Link to Spreadsheet](#)

## Illustrative Map of a Potential BANCOR Network

- BANCOR - The BANCOR network token, backed by EtherETH, DGD, DGX, REP and GNT are standard Ethereum-tokens
- NEW - New smart tokens created (e.g. crowdfunding campaign, a community currency, etc.)
- Smart tokens hold reserves (arrows point to the reserve tokens)
- Token-changers are 100% backed, and hold two or more reserves



## Price Calculation Per Transaction

The actual price of a smart token is calculated as a function of the transaction size.

R - Reserve Token Balance

S - Smart Token Supply

F - Constant Reserve Ratio (CRR)

- $T$  = Smart tokens received in exchange for  $E$  (reserve tokens), given  $R$ ,  $S$  and  $F$

$$T = S \left( \left( 1 + \frac{E}{R} \right)^F - 1 \right)$$

- $E$  = Reserve tokens received in exchange for  $T$  (Smart tokens), given  $R$ ,  $S$  and  $F$

$$E = R \left( \sqrt[F]{1 + \frac{T}{S}} - 1 \right)$$

[Mathematical proof available](#)<sup>7</sup>

<sup>7</sup> The mathematical proof is available online at <https://goo.gl/HXQBUr>

## Summary

The Bancor protocol standardizes smart tokens, enabling asynchronous price discovery and continuous liquidity for cryptocurrencies using constant ratios of reserve tokens held through smart contracts, acting as automated market makers. The Bancor protocol enables the creation of hierarchical monetary systems with no liquidity risk. The BANCOR network token will be used to establish the first decentralized interconnected currency exchange system which does not rely on matching bid and ask orders, thus remaining liquid irrespective of its trading volume. This system proposes the first technological solution for the *Coincidence of Wants Problem* in asset exchange.

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